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SYSTRON-DONNER
CORPORATION

SYSTEMS ENGINEERING

950 GALINDO CONCORD, CALIFORNIA

INSTRUCTION
MANUAL

MODEL 230/231

DIGITAL VOLTMETER SYSTEM

SYSTRON-DONNER CORPORATION
950 Galindo Street
Concord, California
TW/jn
10/10/60

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INTRODUCTION 1.1

The Model 230 Digital Voltmeter consists of the Model 1230 DC to Time Converter and the Model 1231 Digital Voltmeter Indicator. The units provide for the measurement of DC voltages with an accuracy of ±.05%, ±1 count with manual selection of four full scale ranges of 1, 10, 100, and 1000 volts. The polarity of the input voltage is automatically detected and indicated.

The Model 231 consists of the Model 1230 and Model 1231 and the Model 2022 Program-Range Unit. The Model 2022 provides automatic selection of the four ranges.

SPECIFICATIONS 1.1

Model 230 1.1-1

Input Impedance:	1 megohm, all ranges
Input Voltage Range:	±.0001 to ±1100.0 volts
Ranges:	Manually selected nominal full scale ranges of 1, 10, 100 and 1000 volts.
Visual Indication:	Five "Nixie" indicators with automatic decimal indication. Edge lighted polarity and function indicator.
Accuracy:	±.05% of full scale ±1 count.
Maximum Sampling Rate:	25 per second
Electrical Indication:	Ten-line-per-digit and one line for each possible polarity, decimal and function. The indicating lines are negative 10 or more volts; all others are at ground or positive.

Model 231 1.1-2

Automatic selection of the four ranges provided by the Model 2022.so that the indication is never less than 01000 or more than 11000 for any voltage between 0.1 volt and 1100 volts.

INSTALLATION 2.1

The Model 230/231 may be installed in any well ventilated location. The Model 1231 is placed immediately above the Model 1230 so that it shares the cooling fan of the Model 1230. The two units are connected with the 50 pin cable provided.

If the Model 2022 is used it is placed just below the Model 1230. The Model 2022 is connected to both the Model 1230 and Model 1231 with 50 pin cables. These cables are identical and may be used interchangeably.

Additional converters may be connected to the Model 2022 using the appropriate connectors on the rear of the Model 2022.

A special cable may be used to connect one additional converter to the Model 230 without the use of the Model 2022.

OPERATION 2.2

Energize the equipment. Allow several minutes for the equipment to warm-up. About thirty minutes is required for the oven-mounted components to stabilize for maximum accuracy. Set the Range Selector to the desired range or to EXTERNAL for automatic range selection with the Model 2022 in the DC Function. If the Model 2022 or an external converter is not used, the Model 230 is in the 10 volt range when the Range Selector is placed in the EXTERNAL position.

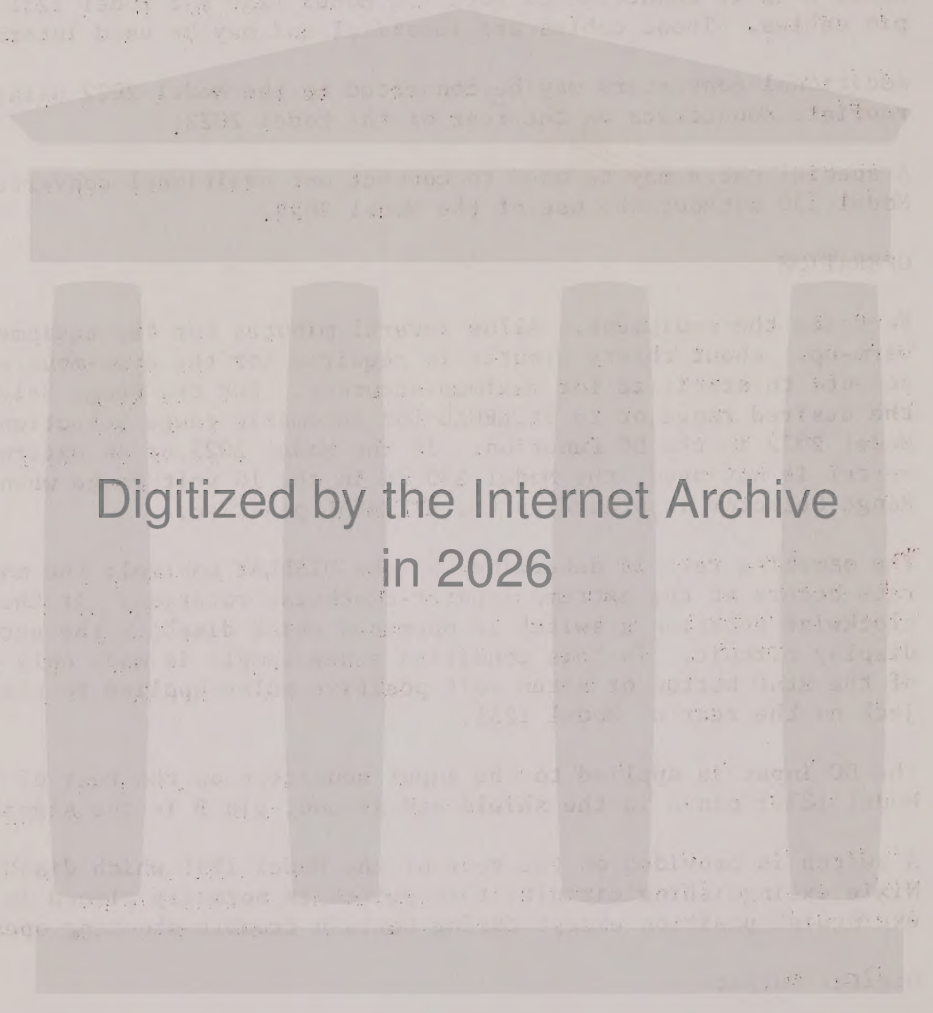
The sampling rate is determined by the DISPLAY control; the maximum rate occurs at the extreme counter-clockwise rotation. At the extreme clockwise rotation a switch is operated which disables the automatic display circuit. In this condition a new sample is made only command of the READ button or a ten volt positive pulse applied to the Read jack on the rear of Model 1231.

The DC input is applied to the input connector on the rear of the Model 1230; pin A is the shield and ground, pin B is the signal.

A switch is provided on the rear of the Model 1231 which disables Nixie extinguishing circuit; this switch is normally placed in the extinguish position except during certain trouble shooting operations.

Digital Output

The electrical indication of the Voltmeter is available at the 75 pin connector on the rear of the Model 1231. These outputs are designed to operate the Model 1401 Digital Recorder. The connection are shown in Figure 3-1



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INTRODUCTION 3.1

The Model 1231 Digital Voltmeter Indicator is designed for operation from the Model 1230 DC to Time Converter. It contains four decades, a 1 megacycle oscillator, and a gate controlled by the output of the Converter to provide an indication directly in volts of the input applied to the Converter. In addition to the Visual indication, a tne-line per decade digital output is provided which is suitable for operation with the Model 1401 Digital Recorder, the Model 1500 Remote Indicator, or other suitable data recording or indicating devices.

The Model 1231 which has no self-contained power supply draws its power from the Model 1230. All necessary connections are made through 50 wire cable at the rear of the instrument.

The Model 1231 is normally fastened to the Model 1230 at the gussets so that the two form one unit. With the interconnecting cable in place, energize the Model 1230. After a few minutes warm-up, the Model 1231 will indicate voltage applied to the input of the Model 1230 according to the position of the Range Selector. The decimal point placement is indicated by the neon glow-lamps between the digital indicators.

The rate at which the Model 1230 operates is controlled by the DISPLAY control of the Model 1231. This control sets the length of time the indication is displayed before the Model 1230 is recycled and a new measurement is made. If the DISPLAY control is placed in the ∞ position, readings are made only on command.

The READ button resets the indicator and starts a new reading at any time when it is depressed. A ten volt positive pulse applied to the READ jack at the rear of the instrument duplicates this function.

The INHIBIT DISPLAY ON-OFF switch at the rear of the instrument controls the display of the indicators during the sampling period. When placed in the ON position, the illumination of the indicators is dimmed while the decades are counting to the new indication.

The DIGITAL OUTPUT connector provides connection to the digital outputs of the decades and the range and polarity outputs of the Model 1230, as well as control connections for operation of the Model 1401 Digital Recorder. The connections are listed in figure 3-1.

DIGITAL INFORMATION

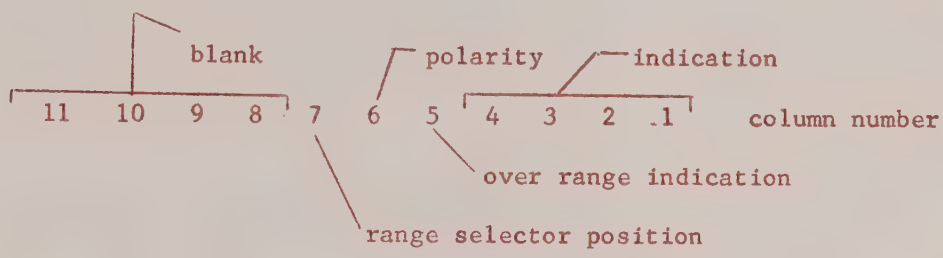
INDICATOR PIN NUMBER	DECADE / DIGIT	OUTPUT PIN NUMBER				
		1's	10's	100's	1000's	10,000's
13	1	1	13	24	34	44
13	2	2	14	25	35	45
11	3	3	15	26	36	
10	4	4	16	27	37	
9	5	5	17	28	38	
7	6	7	18	29	39	
6	7	8	20	30	40	
5	8	10	21	31	41	
4	9	11	22	32	42	
3	0	12	23	33	43	53

FUNCTION	OUTPUT PIN NUMBER
polarity "+" (blank)	63
"-"	62
RMS volts	54
PEAK volts	55
AVERAGE volts	56
kilohms	57
spare	58
spare	59
Calibrate	60
Decimal Position #0	76
#1	65
#2	66
#3	67
#4	70
#5	71
#6	72
#7	73
#8	74
blank	64
end of count	80
reset inhibit	79
+300 volts	78
ground	82

Figure 3-1

When the Model 1231 is operated with the Model 1401 the minimum display time cannot be used or erratic printing will result.

When the Model 1231 is connected to the Model 1401 with a standard 1230 to 1401 cable the following format is printed.

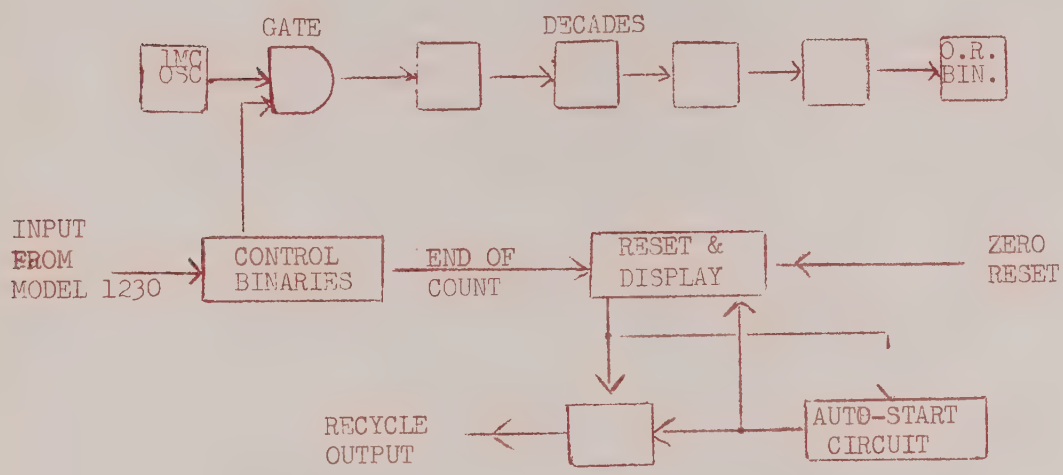


column five: "0" or "1" indicates within range;
"2" indicates over range

column six: "blank" = "+") DC volts
"-" or *= "-")
1 = RMS volts
2 = Peak volts
3 = Avg. volts
4 = Kilohms
7 = Calibrate voltage

column seven: Indicates decimal location "1" indicates placement to extreme right of indication; "2" indicates placement between columns 1 and 2; etc. "0" indicates the ZERO position of the Model 1230 Range Selector. "blank" indicates the CALIBRATE position.

The Model 1231 is essentially a special purpose time interval meter. The major components are shown in block form in Figure 3-2.



BLOCK DIAGRAM
Figure 3-2

The input to the decade chain is the output of the one megacycle oscillator conducted through the gate. The control binaries accept the output of the Model 1230 and produce a control voltage which allows the gate to conduct the 1 MC signal during the length of time between the two pulses from the Model 1230.

The control binaries also produce the end-of-count signal which initiates the start of the display period when the reading of the Converter is completed and recycles the ramp generator of the Converter. At the end of the display time the display and reset circuits return the decades and control binaries to their reset condition and allow the Model 1230 to make another reading.

The auto-start circuit starts the voltmeter when first energized and also recycles the two units in case one of the output pulses is not produced by the Converter during calibration adjustments.

The sequence of operation is as follows, starting from the time at which reset signal is produced: The recycle signal goes negative releasing the ramp generator in the Model 1230 allowing it to start its linear sweep. Within 20 milliseconds two output pulses are produced by the Converter. The control circuits open the gate at the time of the first pulse allowing the decades to count the output of the 1MC oscillator. The gate is closed at the second pulse. At the same time the end-of-count voltage goes negative and starts the display generator which controls the time. The counts accumulated by decades are displayed by the indicators.

At the end of the display time the reset generator produces pulses to reset the decades to "0000" and to ready the control circuits to receive another pair of pulses from the converter. The voltages are represented in figure 3-3.

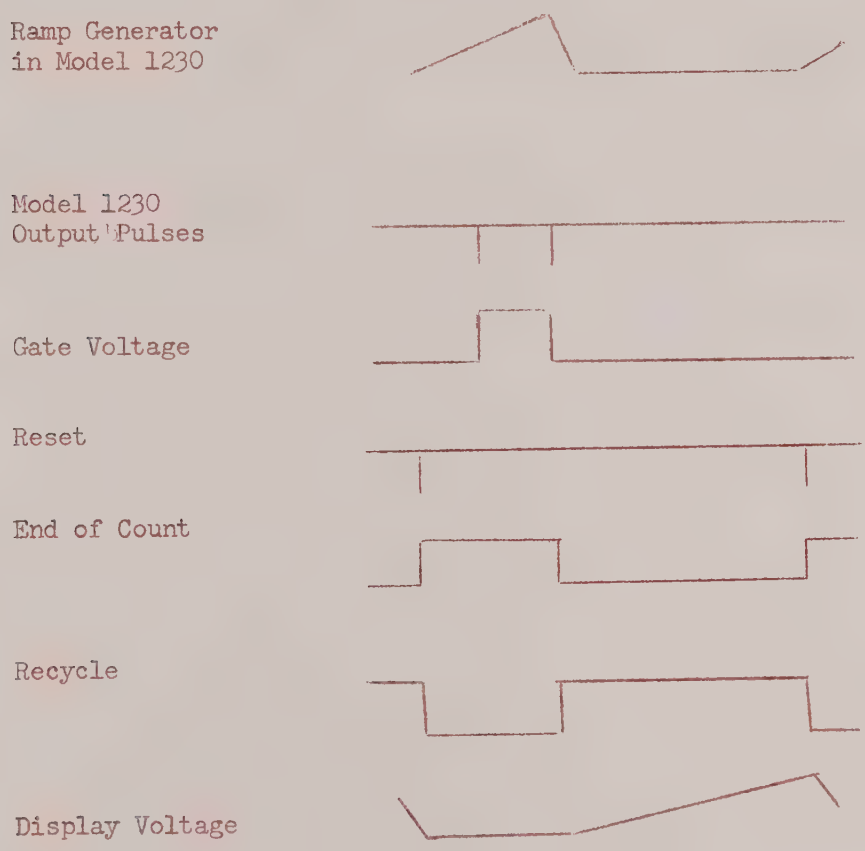


Figure 3-3

Shaped positive pulses are applied to the pentode gate count input. A gate level which is normally -10V is applied to the gate level input. Under this condition the pentode gate is closed and will not pass any of the count pulses. When the gate level rises to 0V the pentode gate is opened. Count pulses will be amplified and will trigger the 1MC drive flip flop. This flip flop drives the 1MC MBS tube through a pair of amplifiers.

V11 is a conventional pentode gate which requires that the voltage on both its control grid, pin 1 and its suppressor grid pin 7 be at 0 volts before plate current will flow.

The control grid is normally biased to approximately -9V by voltage divider R111 and R110. The cutoff voltage for the control grid is -6V so this grid is normally cut off. The count input pulses are positive pulses of 10 volts amplitude and 0.4 microseconds wide. These pulses are of sufficient amplitude to overcome the bias and turn the control grid on during the width of the pulse.

If the suppressor is at -10V the control grid turning on will have no effect on the plate. If the suppressor is at 0V then plate current will flow during the time that the positive pulses overcome the bias on the control grid. Inductor L103 shapes the change in plate current into large negative pulses.

V10A provides a low impedance source of voltage for the screen grid of the gate.

The control binaries receive start and stop input pulses and from these generate the gate level used to control the counting time of the MBS tube decade stages. The gate level is normally low and goes high during the time that the decade counting stages are counting.

The control binaries also generate an end-of-count signal which goes negative at the end of the counting period and stays negative until the control binaries are reset. The end-of-count signal is used to notify other control circuitry of the instrument that the count has been completed and can be displayed and then reset and to recycle the ramp generator in the Model 1230. The end-of-count signal is also used to notify external equipment such as a printer to start its printing cycle.

The circuit consists of two flip-flops and one gate. These units are shown in block diagram form in Figure 3-4.

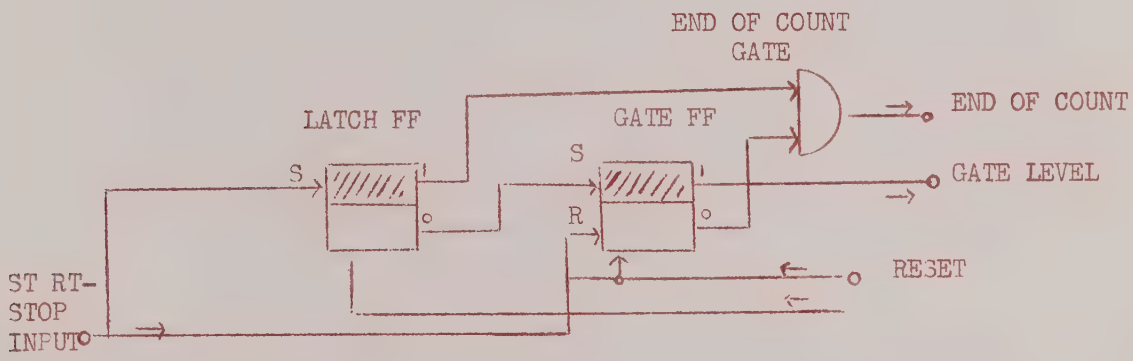


Figure 3-4

The two flip flops are designated as the latch flip flop and the gate flip flop. Each flip flop is shown symbolically as a one-half shaded square. Initially the two flip flops will receive a reset pulse. This will put the flip flops in the state shown where the shaded section represents the normally conducting side of the flip flop. The voltage at the output of this shaded section or the ONE output will normally be low.

The first input pulse triggers the latch flip flop to its set state. The transition of the latch flip flop to its set state will in turn trigger the gate flip flop to its set state causing the gate flip flops normally low output to go high. This output is used as a gate level to control the voltage on the suppressor grid of the pentode gate. During the time that the gate level is high, pulses applied to the control grid of the pentode gate will be amplified and then counted by the decade counting stages. When a stop input pulse is received on the reset (R) input of the gate flip flop, the gate flip flop will be returned to its reset condition. The gate level will then return to its normally low level and counts will stop entering the decade counting stages.

Since the latch flip flop is now in its set state, further start and stop input pulses will have no effect on the control binaries. Thus, after being reset, the control binaries will generate only one on gating level.

The end-of-count gate is a diode gate whose logic is such that the end-of-count signal will normally be high and will drop negative only when the latch flip flop is in its set condition and the gate flip flop is in its reset condition. This particular arrangement exists only after the two flip flops have gone through a start and stop gating cycle. The output of this gate is called the end-of-count signal. This signal then acts as a command to the display and reset circuit, to start the display interval. At the termination of the display interval, the display and reset circuits generate reset and clear-set pulses to reset the control binaries and the remainder of the instruments to their reset state to allow starting of the count cycle over again. The end-of-count signal is also used by external equipment such as a printer to command the printer to start its printing cycle. In this case the printer then inhibits the resetting of the instrument until the print cycle has been completed.

The start and stop inputs to the control binaries are shaped negative pulses approximately 10 volts in amplitude and 0.4 microseconds wide. The latch flip flop is a conventional flip flop with cathode biasing. The cathode bias resistor is broken up into two components, R171 and R172. These two are selected so that their junction is at a voltage which is approximately 10V negative with respect to the cathode. This voltage is used through CR109 to limit the negative excursion of the normally off grid. This increases the sensitivity of the latch flip flop to start input pulses since the negative start input pulse which is amplified by the left-hand section and then appears as a positive pulse on the grid of the right-hand section does not have as far to travel until the voltage on the right-hand grid is within the grid bias region and regeneration occurs, causing the flip flop to flip to its set state.

When the flip flop is switched to its set state, a negative transient is coupled through C139 and CR111 to the gate flip flop, causing it to switch to its set state. CR111 is used to prevent loading of the gate flip flop by the latch flip flop. The gate flip flop is identical to the latch flip flop.

The normally conducting or normally low plate of the gate flip flop is used to generate the gate level. External to the control binaries the gate level is connected to the suppressor grid of a 6AS6 pentode tube and a 470K resistor to -300V. A diode clamp limits the positive excursion of the gate level to 0 volts. The voltage divider consisting of the 470K resistor and R142 is necessary since the plate level does not quite rise to ground. C112 acts as a speed-up capacitor to compensate for the stray capacity on the gate level line.

The normally high output of the latch flip flop and the normally low output of the gate flip flop are used to generate the end-of-count signal. In order to have a signal which is normally positive a few volts, dividers R219 and R140 and R170 and R141 to +300V are used. If either of the inputs to the end-of-count gate are in their high state, then the junction of the CR102, CR103, and R186, the 820K resistor, will be pulled positive to approximately +10 volts. Only when both of the inputs to the end-of-count gate drop to their low state will the 820K resistor be able to pull the end-of-count gate to its low state of approximately -30V. The end-of-count signal is at +10V when the control binaries are reset. It stays at +10V during counting, drops to -30V at the end of counting and then stays there until the end of the display period. At this time the control binaries are reset and the end-of-count signal returns to -10V.

Upon receipt of an "end-of-count" signal from the control binaries at completion of counting, the display and reset circuits allow the information in the Nixie indicators to be displayed for a period of time. The length of this display time is adjustable from .001 second to 5 seconds. At the end of the display time the circuit generates reset and clear-set signals to reset the counter stages and the instrument to a state such as to be ready to start a new count.

The display time can also be adjusted for an infinite period (∞). The resetting must then be manually initiated by pressing the READ push-button.

The display and reset circuits consist of a cathode follower, display generator or Miller integrator, a one-shot, and a blocking oscillator. These units and associated external controls are shown in block diagram form in Figure 3.5.

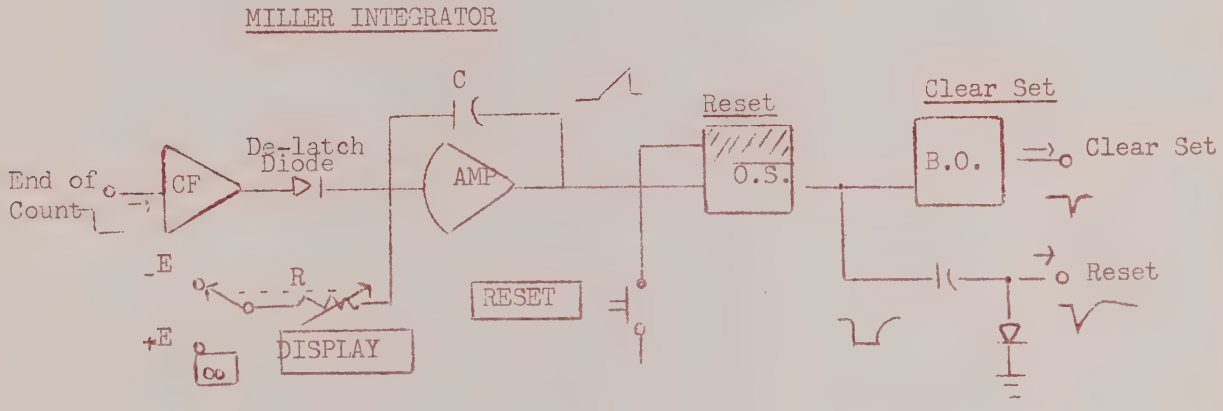


Figure 3-5

During the time the conversion is made by the Model 1230 the end-of-count signal from the control binaries is a voltage level positive of ground. In this condition the cathode follower will, through the de-latch diode, hold the output of the Miller integrator in a low state. When the end-of-count signal goes negative, the de-latch diode becomes back-biased, allowing the output of the Miller integrator to rise at a rate of $\frac{E}{RC}$ $\frac{\text{volts}}{\text{second}}$. At some particular output voltage of the Miller integrator, the reset one-shot will go into its timing period, generating a negative reset pulse and a positive start inhibit pulse. The negative reset pulse is used to reset the control binaries and the drive flip flops in the MBS decade counting stages.

The negative transient of the reset pulse is also used to trigger a blocking oscillator. The blocking oscillator generates a clear-set pulse to clear and then set the MBS tubes to a particular number, normally zero.

The time that it takes the output of the Miller integrator, upon receipt of the end-of-count signal, to reach the level to trigger the one-shot can be adjusted by varying the adjustable resistor R. This time is called the Display Time. The voltage E is normally a negative voltage which allows the output of the Miller integrator to rise positive and thus trigger the reset one-shot. It is possible, however, by rotating the DISPLAY potentiometer to its extreme clockwise position to switch this voltage to a positive level. When the DISPLAY potentiometer is in its extreme clockwise position the output of the Miller integrator will never rise and the count information displayed in the Nixie indicators will be retained indefinitely. In this condition the instrument must be manually reset by pressing the READ push-button. The reset and clear-set pulses to the instrument will occur immediately.

The end-of-count signal is a voltage level which prior to counting and during counting is approximately 10 volts positive of ground. Upon completion of counting this signal drops to a negative level of approximately -30 volts. When the end-of-count signal is in its positive condition, cathode follower V20A through diode CR114 pulls the control grid of the Miller integrator, V20B, into its positive grid region. The plate of the Miller integrator is thus conducting hard and is in a low-condition. When the end-of-count signal drops to its negative level CR114 becomes back-biased, and since the 10 meg DISPLAY potentiometer is returned to a negative voltage, V20B will attempt to cut itself off. This will result in a positive rise at its plate. This positive rise will be capacitively coupled back to the grid thru C140. This negative feed-back causes the plate voltage to rise at a constant rate. Due to the high gain of the pentode the rate or slope of the positive going ramp function is mainly dependent upon the voltage which supplies the potentiometer and the time constant of the 10 megohm adjustable DISPLAY potentiometer and capacitor C140.

The cathode output of V20A also controls the extinguish circuit, the recycle output driver and the auto-start one-shot.

The reset inhibit signal is provided by grounding the grid of V20B before the instrument is reset. This will cause the plate of V20B to return to its low state and remain there until the printout is completed. At this time the plate will again start rising positively.

V21, the reset one-shot, is a mono-stable multivibrator. In one condition it will remain stable but if triggered to its opposite condition, it will remain there for a period of time determined primarily by R203, C133, and +300 volts. Initially the right-hand section of this tube is conducting as shown by the shaded section and the left-hand section is cut off. When the plate of the Miller integrator is in its normally low condition, CR115 will be back-biased. As the plate of the Miller integrator begins to rise positive, a point will be reached where divider R194 and R195 will pull the left-hand grid of V11 into its conducting region, through CR115. At the point at which the loop gain of the reset one-shot V11 becomes greater than one, the reset one-shot will become regenerative and V11 will switch to its astable state with the left-hand side conducting and the right-hand side cut off. The right-hand side will not remain cut off since it is only held cut off by the charge on C133. The charge on C133 will discharge through R203. The right-hand grid will attempt to return to the DC voltage that R203 is connected to. The time that it takes for this grid to reach its grid-bias region will be dependent upon C113, R203, and the voltage to which R203 is returned. When the voltage rises to the grid-base region of the tube, the loop gain will again become greater than one and the circuit will switch back to its stable condition with the right-hand side conducting and the left-hand side cut off. The right-hand plate is used to reset the various flip-flops throughout the instrument to their initial positions. This negative-going transient is normally AC coupled as shown in Figure 3-6.

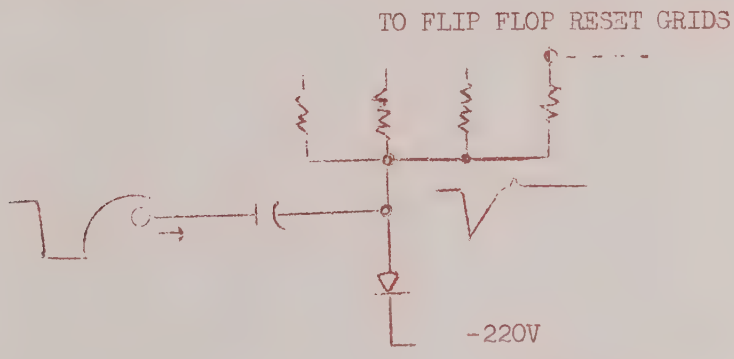
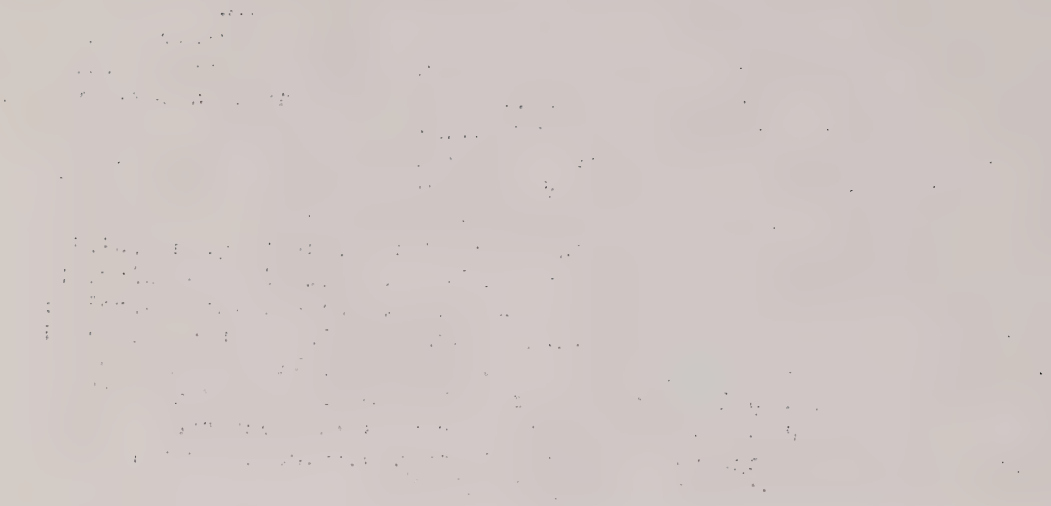


Figure 3-6

The diode is in series with the grid return resistors of the reset side of various flip-flops in the instrument. The negative pulse is developed across the back impedance of the diode but the normal grid bias current of the flip-flops and the positive pulse developed as V11 switches back to its stable state, produce a negligible voltage drop across the forward impedance of the diode.

V22 is a blocking oscillator connected so that regeneration takes place from the screen grid to the control grid.

The negative transient on the right-hand plate of V21 is coupled through CR116, CR117, and C134 to the screen grid of the clear-set BO, V22. The control grid of V22 will normally be held cut off by voltage divider R206 and R207. The screen grid will, however, be in a high positive state due to R205. The negative transient introduced into the screen grid from V21 will be coupled through transformer T101 and appear as a positive pulse on the control grid, attempting to turn V22 on. V22 turning on will cause the screen grid to go more negative. The action is thus regenerative and will continue until the tube is conducting hard. It will stay in this condition until the tube current saturates the transformer. When the transformer saturates, it can no longer hold the control grid positive in the opposite direction and cuts the tube off, allowing the plate to go positive. The output of the plate of the screen grid to control grid coupled blocking oscillator is a large negative pulse with a relatively flat bottom. The width of this pulse is approximately 10 microseconds as determined by the pulse transformer. This pulse is used as a clear-set pulse to the MBS tubes. The action of this pulse is such that it first clears a beam tube stage and then sets it to a particular number as determined by the wiring of the individual stage.



The zero reset pulse from the Model 1230 is connected into the output of the reset circuits so that every circuit except the latch binary is reset by the pulse.

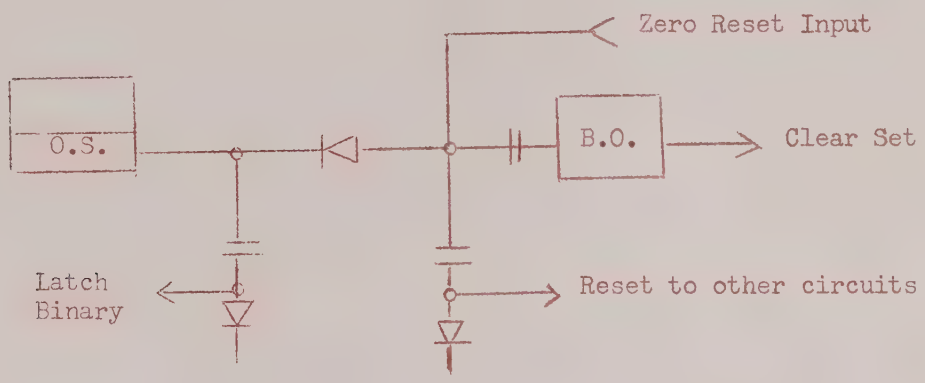


Figure 3.7

In this way the zero reset pulse closes the gate and resets all indicate zero, but still allows the control binaries to produce the end-of-count signal.

EXTINGUISH CIRCUIT

The extinguish circuit consists of V17 and one half of V18. The output voltage pin 3 of V17 is at about ground except during the display period when it is about +200V. When voltage is at ground insufficient current is available to operate the Nixie Indicators and very little glow is present. The output of the circuit is controlled by the end-of-count voltage which is connected to the cathode of V18 through V20A.

AUTO START CIRCUIT 3.3-5

The auto-start circuit is an astable multivibrator built around V19. The right-hand section of the tube is held cut off by the charge placed on C114 by the negative voltage of the end-of-count signal conducted by the forward impedance of diode CR106. When the end-of-count voltage goes positive at the time the instrument is reset, the tube is held cut off for a length of time determined by the time constant of C114 and R157 which is several times larger than the time required for one conversion of the Model 1230. Should less than two pulses be produced by the Converter the end-of-count voltage does not go negative and V19 triggers to its opposite state with right-hand side conducting and the left-hand side cut off.

When V19 switches, the negative transient at the left-hand plate is used to trigger the reset one-shot, V21. A negative step voltage is also coupled to the recycle driver through V133.

OSCILLATOR 3.3-6

The oscillator consists of a two-stage amplifier with a bridge feed-back circuit. The first stage V12A is a triode with an LC tuned plate load. The triode operates as a voltage amplifier and drives the second stage, a pentode which operates as a cathode follower power amplifier. Feed-back is taken from the pentode cathode follower output and fed to the input of the bridge in the grid-cathode circuit of the triode amplifier V12A.

The bridge allows a voltage of only one frequency to be effective in the circuit because of the degeneration and phase shift provided by this circuit. A positive feedback voltage is provided by the voltage divider consisting of the lamp and R103. The lamp is used as a non-linear resistor to stabilize the amplitude of oscillation. If the amplitude of oscillation tends to increase, the current thru the lamp also tends to increase. When the current increases the filament of the lamp becomes hotter making its resistance larger. The effect will be to decrease the positive feed-back, thus maintaining the amplitude constant. The inverse effect takes place when the oscillator output attempts to decrease. This action provides excellent frequency stability by restricting the operation of the triode section to its linear range.

Negative feedback to maintain a constant frequency is provided by the voltage divider consisting of RXX, the crystal. The equivalent circuit of the crystal is a high Q series RCL circuit. At resonance the impedance of the crystal is a minimum and a pure resistance. Any tendency of the output frequency of the oscillator to change from the resonant frequency of the crystal will change the effective impedance of the crystal resulting in increased negative feed-back and phase shift tending to cancel out the frequency change.

The resonant impedance of the crystals varies from unit to unit. The value of RXX is chosen at the factory so that the voltage dividing ratio of the bridge will produce the proper amount of drive to the crystal. Higher values of RXX will drive the crystal harder. Excessive overdriving may result in possible damage to the crystal. If the value of RXX is too small, there will be insufficient feed-back to allow the oscillator to start oscillating.

L101 and C104 are tuned to the crystal frequency to provide maximum gain and zero phase shift in the triode amplifier stage. The output of the oscillator is taken from the plate of the pentode amplifier V12B. Since the plate is not involved in the feed-back loop of the oscillator, changes in external loading will have a minimum effect on the oscillator frequency and stability. The use of a pentode in this stage further decouples the output from the oscillator feed-back loop.

The Plate Tune Control adjusts the oscillator for maximum stability and maximum oscillator output. Normally it does not require any adjustment unless the tube or some other component is replaced.

RXX, one of the resistors in the bridge circuit surrounding the crystal, adjusts the amount of drive applied to the crystal. This resistance should not need to be changed unless the crystal is replaced. It is chosen to provide mainimum drive to the crystal. Increasing the resistance increases the drive. Nominal value of the resistance is 470Ω. If it is necessary to replace this resistance, a satisfactory selection can usually be made by starting with a resistance which is higher than 470Ω, 680Ω for instance, and substitute smaller resistances. The smallest resistance at which the circuit still oscillates is the proper value. Too large a drive to the crystal will cause instability and possible damage to the crystal. A properly adjusted oscillator may take as long as two minutes to start oscillating when the instrument is first turned on.

DECADES

Four decades, which utilize the Magnetron Beam Switching Tube, are used in the Model 1231. The stages are of three similar types: 1 one megacycle stage, 1 one hundred kilocycle stage, and 2 ten kilocycle stages. The operation of the decades is described in the section on Magnetron Beam Switching Tubes included in this manual. The unique circuitry of the three types is described below.

In the one megacycle stage, the output of the driving binary, V9, is differentiated by inductors L3 and L4 and applied to the grids of amplifier V1. The outputs of V1 are used to drive the switching grids of the Beam Tube. The spade supply for the Beam Tube is provided by cathode follower V10B.

The 100 kilocycle decade is driven directly from the plate of the binary V3 which is built around a high current tube to provide satisfactory output voltage at the operating frequency.

The 10 kilocycle decades are similar to the 100 kilocycle decade except that a slower binary is used and no clamp diodes are required on the switching grids.

The Off Scale Binary is driven by the output of the last decade. It is used to drive the fifth nixie indicator and OFF SCALE indicator through a system of gates using the digital output of the last decade. Because the output swing of the amplifier in the Model 1230 is limited by its clamp circuit the digital indication will not exceed approximately 12000 depending on the clamp adjustment.

Note: Section 3.5 follows

MAGNETIC BEAM SWITCHING TUBE

INTRODUCTION

The Beam Switching Tube is a 10-position high vacuum, constant current distributor. It has applications in the fields of electronic switching and distribution, such as counting, timing, sampling, frequency division, coding, matrixing, telemetering, and controlling.

The most obvious advantages of the Beam Switching Tube are its compactness in terms of the number of components necessary to perform an equivalent function and its high life expectancy. The MBS Tube has a rated life of 50,000 hours as compared to a conventional vacuum tube rated life of 10,000.

The Beam Switching Tube consists of 10 identical arrays, located radially about a central cathode (Fig. 3.5-1)

Fig. 3.5-1

Each array consists of:

1. A spade which automatically forms and locks the electron beam.
2. A output target which makes the beam current available with constant current characteristics.
3. A high impedance switching grid which serves to switch the beam from target to target.

A small cylindrical magnet is permanently attached to the glass envelope to provide a magnetic field which, in conjunction with an applied electric field, comprises the crossed fields necessary for the operation of this tube.

THEORY OF OPERATION

Basic Theory

In order to more fully understand the Magnetic Beam Switching Tube, it is necessary to review that portion of physics describing the motion of an electron in a static electric and magnetic field.

Electric Field

If a battery E is place across two plates, as shown in Fig. 3.5-2. an electric field will exist between the two plates.

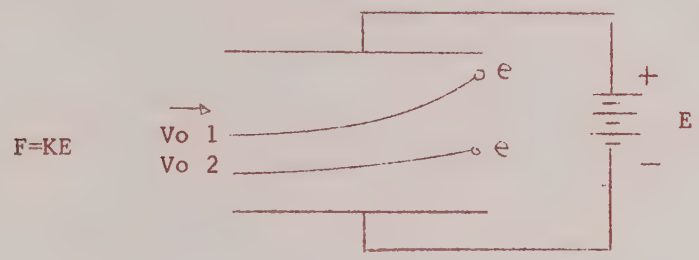


Fig. 3.5-2

Any electron in this electric field will have a force F exerted on it. The magnitude of the force will be proportional to the electric field. The direction of the force will be such that the negatively charged electron will be attracted to the positive plate. The path of an electron in the electric field, will be dependent upon its initial velocity. If an electron were placed in an electric field with zero initial velocity, it would be merely attracted towards the positive plate. If, however, electrons were projected into the electric field with different initial velocities , they would have paths similar to those shown in Fig. 3.5-2. The individual paths would be dependent upon the relative magnitudes of the electric field and the initial velocity. A practical application of this is a cathode ray tube using electrostatic deflection plates.

Magnetic Field

An electron in a magnetic field will also have a force exerted on it. This force will however, be dependent, not only on the magnitude of the magnetic field, but also upon the velocity of the electron. The force will be exerted at right angles to the direction of motion of the electron. In Fig. 3.5-3 the crosses

represent a magnetic field B, having a direction perpendicular to the paper and directed into it.

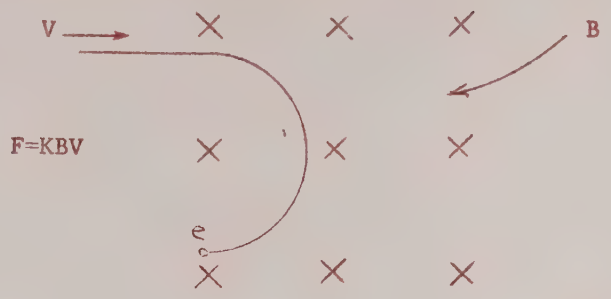


Fig. 3.5-3

An electron placed at rest in this field would remain stationary. This would be true since the force would be zero due to the velocity being zero. If instead an electron was, projected into the field with an initial velocity, the electron would follow a circular path as shown in Fig. 3.5-3. The radius of curvature of the path would be dependent upon the relative magnitudes of the magnetic field and the initial velocity. A practical example of this is a cathode ray tube using magnetic deflection coils.

Combined Electric and Magnetic Fields

Several possible paths for electrons projected into combined electric and magnetic fields with different initial velocities are shown in Fig. 3.5-4.

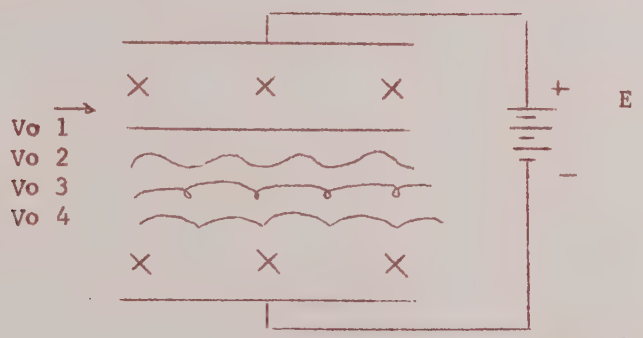


Fig. 3.5-4

For a given electric and magnetic field, there exists an initial velocity such that the vertical component of the two fields will cancel out and the motion of the electron will be that of a straight line. Figure 3.5-5 shows this path, plus the paths of electrons with initial velocities above and below, this value. The paths that electrons follow in perpendicular and electric magnetic fields are called "trochoidal" paths. The important thing to note is that although the individual electrons will follow

trochoidal paths, the general motion of a large number of electrons with different initial velocities is to form a broad beam which will follow an equipotential line. Thus, while for the electric field alone, the paths of the electrons were perpendicular to the two plates, in the combined electric and magnetic field, the average path of the electrons is parallel to the two plates.

Cylindrical Configuration

In the previous discussions, the electric field was formed by two parallel plates. Figure 3.5-5 shows the electric field being formed by two concentric cylinders.

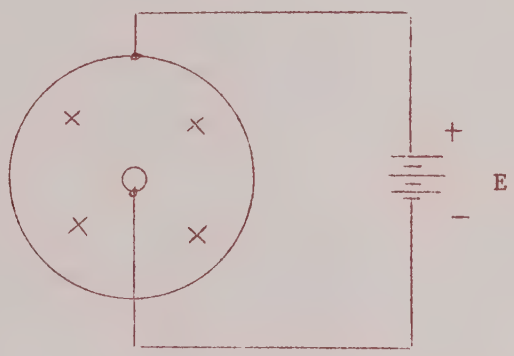


Fig. 3.5-5

The magnetic field is as before, perpendicular to and into the paper. If the center element is a heated cathode, emitting electrons, a typical path of an electron is shown in Fig. 3.5-6

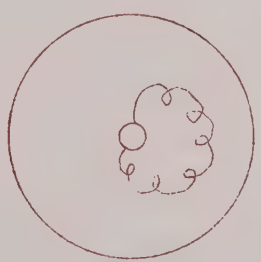


Fig. 3.5-6

By either increasing the electric field E or reducing the magnetic field B, it is possible to increase the arc of travel of the electrons to a point where that they will strike the positive anode, resulting in current flowing in the battery. The resulting current relationship is shown in Fig. 3.5-7.

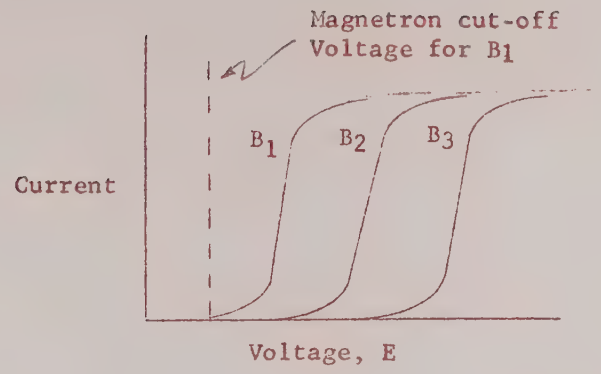


Fig. 3.5-7

The value of an electric field for a given magnetic field in which current starts to flow is called the "Magnetron" cut-off voltage. The operating voltages of the Beam Switching Tube Circuit in the following discussion are well below the magnetron cut-off value.

Spade

Suppose that the single piece cylindrical anode in Fig. 3.5-6 is now replaced by 10 elements which we will call "spades". If all the spades were at a common potential, the configuration would be equivalent to that of Fig. 3.5-6.

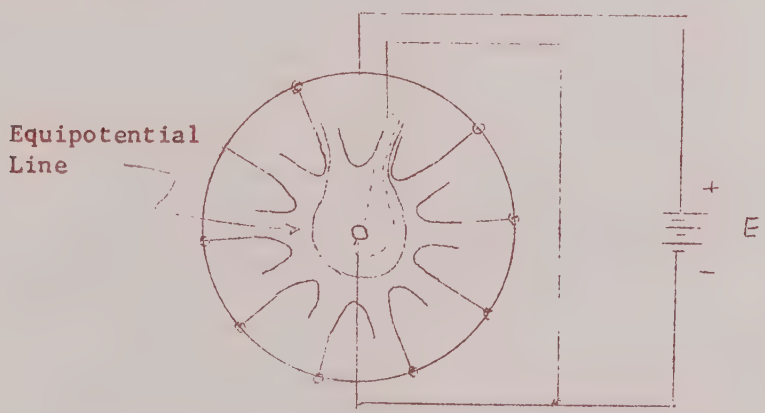


Fig. 3.5-8

As long as the spade potential was below the magnetron cut-off voltage, no current would flow to the spades. Suppose now that one of the spades was placed at zero volts, or cathode potential, and the remaining was connected to E. The electric field would now be as shown in Fig. 3.5-8 and the electrons emitted by the cathode would, as described previously, tend to follow paths parallel to the electric field. The paths of individual electrons would be difficult to describe, but they would be similar to those shown in Fig. 3.5-5. The total effect would be the formation of a beam of electrons with a configuration similar to that shown in Fig. 3.5-8

It would be wise at this time to recall the part the magnetic field plays in this operation. Without the magnetic field, electrons emitted by the cathode would be attracted to all the spades. Thus the effect of the magnetic field is to prevent drawing current to the other spades.

A more practical arrangement is shown in Fig. 3.5-9.

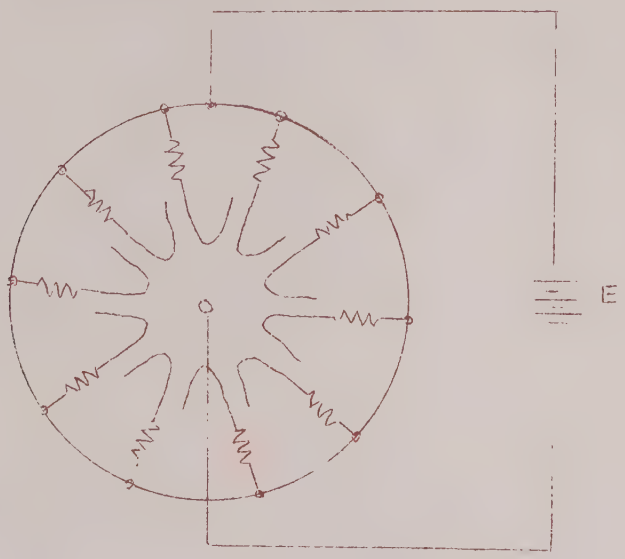


Fig. 3.5-9.

Here we have inserted resistors in series with the spades for control purposes. If one of the spades is brought to within cathode potential, the beam will form on this spade. Each spade has a negative resistance characteristic due to the crossed electric and magnetic fields. Fig. 3.5-10 shows this characteristic.

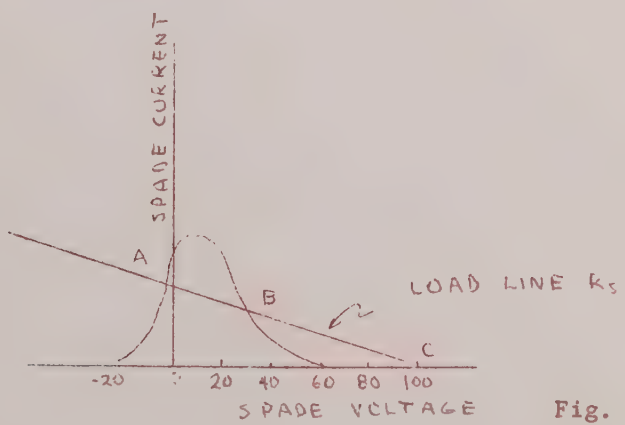


Fig. 3.5-10

As shown in this figure, if the voltage of the conducting spade (that spade to which the beam is directed) is at approximately +12 volts with respect to the cathode, the beam will be going directly towards this spade and the current in the spade will be a maximum. As the voltage on this spade is varied in either direction, the beam moves to one side or the other of the spade and the current decreases since less electrons are striking the spade. Since the voltage on this spade is determined by the current through the spade resistor Rs, the resultant spade current may be determined by superimposing the load line of this resistor on the spade characteristics, as shown in Fig. 3.5-10. This shows that there are three points at which the spade may operate: points A, B, and C. Of these points, point B is unstable since here a change in spade current in either direction changes the spade voltage in such a direction as to cause an additional current in the same direction. In other words, at this point the characteristics exhibit a negative resistance. The two stable points, therefore, are at points A and C. The current required to maintain the stable operating point at A is approximately 10% of the available beam current. The beam then barely skims along the surface of the spade. Notice that the beam is in a stable condition when it skims along one side of the spade, but not when it skims along the other side.

Target Output

The previous circuit performed no useful function since the spades act only to control the beam. Since a spade requires only 10% of the beam to perform its controlling function, the remaining 90% of the beam can be made to do useful work by placing another element in its path called a "target" as shown in Fig. 3.5-11.

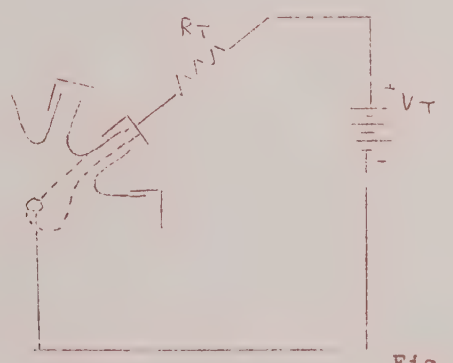


Fig. 3.5-11

The output of the targets exhibit a constant current characteristic as shown in Fig. 3.5-12

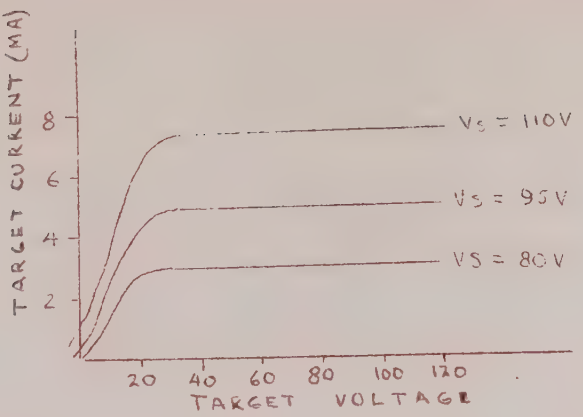


Fig. 3.5-12

This figure shows that for a given spade buss voltage, provided the target voltage is above a certain amount, the target current will be independent of target voltage.

Fig. 3.5-12 shows that the Beam Switching Tube exhibits a knee in its target characteristics at approximately 30 volts above the cathode potential. Below this potential, part of the excess electrons are collected by the next spade. The resultant current flow lowers the potential of this electrode and due to its negative resistance characteristics causes the beam to switch to the next position.

If the same condition exists in all 10 positions; that is, if the target potential drops below the knee when target current flows, the beam will not be stable in any position and will skip around the tube erratically.

The equivalent output circuit of a target for a typical beam tube is a current generator of approximately 5.5 milliamps in parallel with the target load resistor, as shown in Fig. 3.5-13. An equivalent output voltage generator is also shown in this figure.

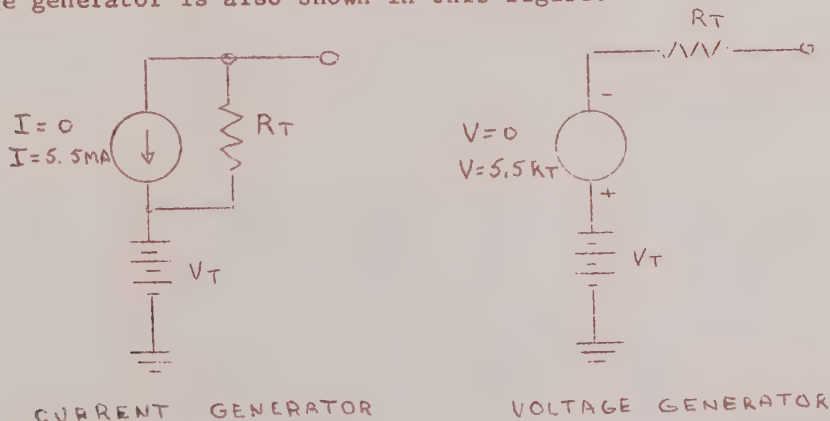


Fig. 3.5-13

Due to the constant current out, the target voltage swing can be varied over a wide range by selection of the target buss voltage and the target resistor value.

Grid Circuitry

In order to cause the beam to switch from one spade-target combination to the next, an additional element is added to the beam tube called the "grid". By dropping the voltage of the grid associated with the conducting spade, this will shift the zero or cathode potential line and form a new configuration of the electric field which allows a small amount of beam current to strike the next spade. Due to the negative resistance characteristics of the spade, when current is striking the wrong side of the spade, the beam will shift and form on this spade. In this manner the beam is switched from one spade to the next. Since this switching is accomplished on an every other spade basis, it is possible to tie every other grid together in two sets. Thus by alternately lowering each set of grids, the beam may be caused to switch around the beam tube from one spade to the next.

The switching speed will be dependent upon the grid voltage pulse and also upon the stray capacity of spades and the value of the spade resistors. Fig. 3.5-14 show the switching voltage required for a typical MBS tube.

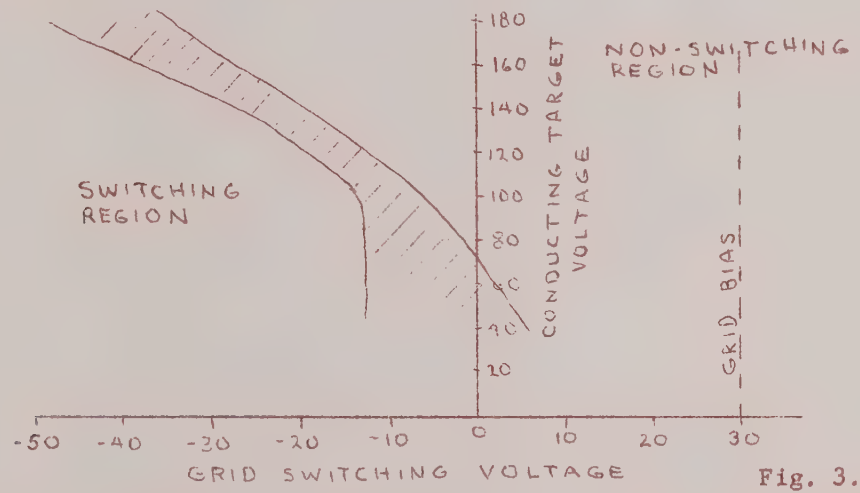


Fig. 3.5-14

The shaded area represents a region where that the beam tube may switch. In order to insure that a beam tube will switch, it is necessary to apply a grid switching volrtage more negative than the shaded area. Variations in the spade buss voltage will further spread the shaded area. In order to keep the beam from switching erratically by itself, it is necessary to apply a positive bias to the grids with respect to the cathode of approximately 30 volts. Fig. 3.5-14 also shows that the higher the conducting target voltage, the larger the grid switching voltage necessary. The conducting targets of MBS tube circuits operating at high pulse rates do not have sufficient time, due to stray capacity on the targets to drop down to their full conducting point. Thus, high speed MBS tube circuits require greater grid switching voltage.

10 KC MBS TUBE DECADE CIRCUIT

Introduction

As shown on the attached MBS decade schematic, the decade counter consists of two sections. The Beam Switching Tube and associated circuitry and the flip-flop driver. The flip-flop driver is a conventional single input Eckles Jordan trigger circuit with two stable states. Its purpose is to provide negative switching pulses alternately to the odd and even sets of grids of the Beam Switching Tube. The 10 KC decade circuit is designed to operate from the target of a previous beam tube decade stage, or from any negative transient sufficient to toggle the flip-flop.

A NIXIE tube is normally used in conjunction with the target swings to indicate the position of the beam in the MBS tube.

Spade Circuit

All 10 spades are connected through individual 150 KΩ load resistors to a common spade buss. The zero spade has an additional 10K resistor in series with it for the purpose of zero setting the beam (See the Clear-Set section. The function of these resistors is to utilize the beam forming and locking characteristics of the spade. This value of resistance is selected so that the load line intersects the curve shown in Fig. 3.5-10, at an area of stable beam switching and locking. If the value of the spade resistor is selected so that it is too small, the load line will not intersect the beam tube characteristics at all and will be incapable of forming a beam. If the load resistance is made too large, continuous switching of these MBS tubes will result. The value of 150K was selected to place the load line in a region of stable switching and cut off.

Circuit Degeneration and Target Output

In order to tolerate wider variations in power supply operating voltages, component variations and changes in beam tube characteristics, degeneration resistors are used in the target buss, spade buss, and cathode circuits. The function of the degeneration is to minimize changes in the spade buss to cathode potential for variations in other parameters of the circuit. The degeneration resistors are chosen so that the spade buss to cathode potential is approximately 110 volts. With this voltage, the beam in the MBS tube is approximately 8 milliamps. 0.75 milliamps of this is used in the spade circuit to develop the 110 volt drop across the 150 K conducting spade resistor. Of the remaining 7.25 milliamperes flowing in the target circuit, approximately 1.75 milliampers flow into the NIXIE tube. This leaves approximately 5.5 milliamperes to be used to develop an output voltage for use with external circuitry such as Printers, etc. Using an 18K target resistor, the voltage drop from a non-conducting target to a

conducting target is approximately 100 volts. The target degeneration resistors are selected so that the target buss voltage is at approxima, tely +40 volts. This means that normally 9 of the targets will be at approximately +40 volts through an 18K resistor, while one of the targets representing the conducting target will be at +40V -100V= -60V. The equivalent output circuit for the targets, both in the conducting and non-conducting state, are shown in Fig.3.5-14a. An RC network is placed in the zero target output to prevent any external devices (ie printer) from stray triggering the next stage and to preserve the target fall time for reliable triggering of the next stage. This reduces its output swing slightly.

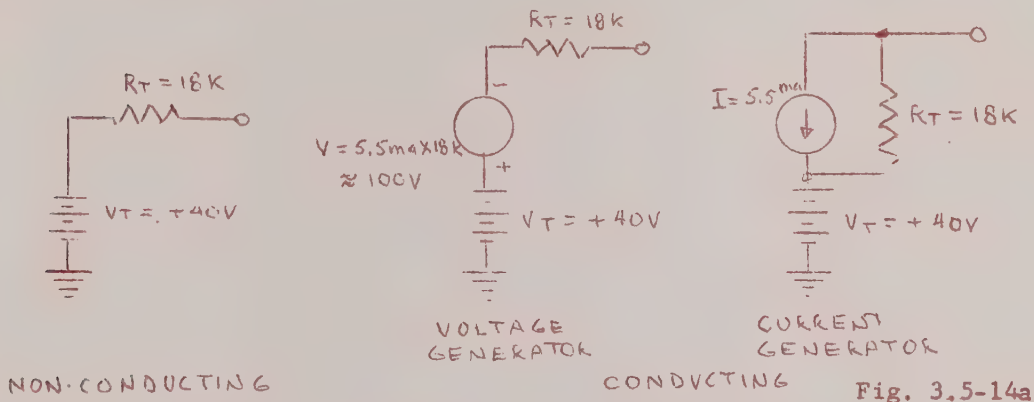


Fig. 3.5-14a

Since the output of the MBS tube is a constant current, any current supplied to external loads will further reduce the available voltage swing. As explained previously, the conducting target voltage should not drop down to the point of the knee in the target characteristic curves.

A rule of thumb is that, the conducting target to cathode voltage should be greater than 70 volts to maintain beam stability.

All of the degeneration resistors have capacity by-passes on them to maintain the voltage generated by them constant during switching of the MBS tube.

Any external loads which are on the targets at all times will effect the target buss potential since they will be drawing current through the degeneration resistors. The MBS tube and its associated circuitry are independent of variations in AC lines due to the use of regulated power supplies and the constant current output characteristics of the target circuit. The target output voltage, however, will be observed to vary with the AC line due to the variations in current requirements of the NIXIE indicator. The current to the NIXIE will change with variations in the unregulated +330 volts. This changes the amount of current flowing through the 18K target resistors, thus causing a variation in the target output voltage with variations in AC line.

Grid Input Circuit

The grid is normally the electrode used for sequential switching since it performs its function without drawing appreciable current. In each

position, the beam is effected only by the individual grid with which it is associated. The grids are connected in two groups. The odd number grids in one group and the even numbered grids in the other. The grids are biased approximately +30 volts, through a voltage divider, with respect to the cathode and each set of grids are in turn pulsed negatively by the opposite plates of the flip-flop driver. The plates of the flip-flop driver are capacity coupled due to the different DC voltage levels. The time constant of the coupling circuit is not critical, except that for high speeds (greater then 10KC) diode restorers are used so that the full plate swing of the flip-flops appear at the Beam Switching Tube grids.

Initial Beam Forming

The two neon bulbs connected between the MBS tube zero spade and the cathode are for the purpose of causing the beam to be formed when power is first applied to the circuit. The beam tube circuit depends upon current flowing through the degeneration resistors in the target and cathode circuits to develop the correct operating voltages across the MBS tube. Initially there would be no current flowing in the MBS tube and, therefore, no voltage drop in the degeration resistors. Without the neon bulbs, the voltage across the tube would be approximately 440 volts. A beam may form in the MBS tube depending upon how the power supply voltages varied during warm-up,but more probably the voltage across the tube would rise to 440 volts. The two neon bulbs, however, fire when the voltage drop across them reaches approximately 154 volts. The neon bulbs thus limit the voltage across the MBS tube to where it is possible for the beam to be formed automatically. By connecting the neon bulbs to the zero spade itself rather than to the spade buss, the beam will normally form on the zero spade.

The spade to cathode voltage is on the order of 110 volts. Therefore, after the beam has formed, the voltage across the neons is always less than their required maintaining voltage of 120 volts. The neon bulbs thus perform no function once the beam has been formed.

Occasionally due to differences in MBS tube characteristics, neon bulb firing and maintaining voltages, and component tolerances, etc., the neons will not always automatically form the beam when power is first turned on. They will, however, hold the voltage drop across the MBS tube to a voltage such that when a clear-set pulse arrives, it will be able to clear-set the MBS tube. Without the voltage being limiting by the neons, the 150 volt clear-set pulse might not be able to overcome the 440 volt drop across the MBS tube.

Reset and Clear-Set

Once a beam has been formed in the MBS tube, it can be advanced around the tube in only one direction. The maximum number of positions that it may be advanced at any one time by the lowering of a leading spade

(any spade located from 1 to 5 positions ahead of the beam) is 5 positions. Thus, lowering the zero spade when the beam is formed on any of the positions 1 through 5 would have little effect, if any. Any zero set circuitry therefore must first clear the beam, if it exists, and then form it in the zero position. The beam can be easily cleared by lowering the spade buss potential to near the cathode potential. The MBS tube is reset to zero (or to any other pre-determined position) by a negative 125 volt clear-set pulse. As this name implies, it first clears the MBS tube and then sets it to a particular number normally zero. This pulse is a negative 125 volt pulse of approximately 10 microseconds width and with a relatively flat bottom as shown in Fig. 3.5-15.

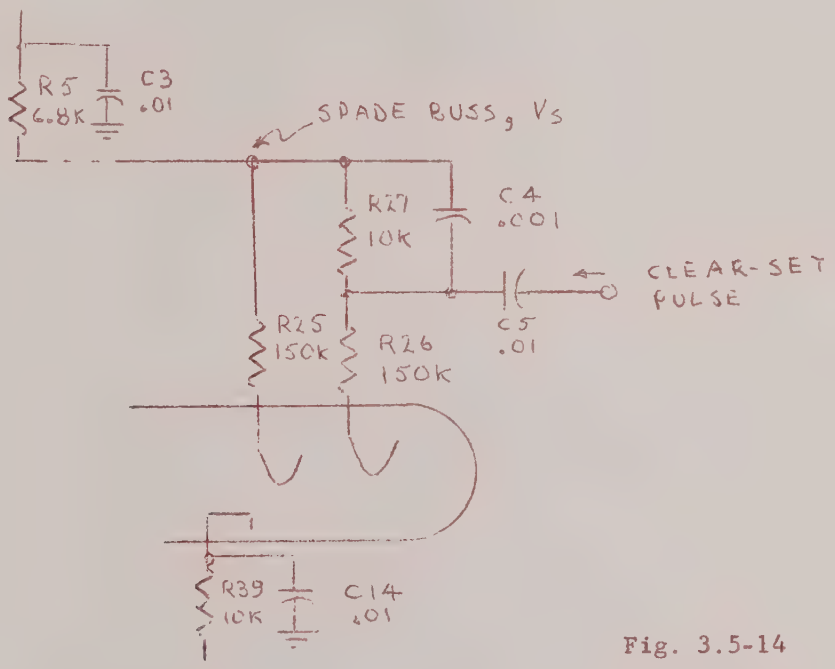


Fig. 3.5-14

The pulse is coupled through C5 to the junction of R27 and R26. The negative leading edge of this pulse will also be coupled through C4, lowering the spade buss voltage. The beam will now extinguish since all the spades are pulsed to below cathode potential. The time constant of C4 and R5, R27 is such that at the end of the 10 microsecond clear-set pulse the spade buss potential will have charged to about 50 volts positive. The time constant, however, of C5 into R26 is sufficiently long such that the zero spade is still below cathode potential. When the clear-set pulse ends, all spades except the zero spade rise to the normal spade buss voltage of approximately 110 volts above the cathode. Beam formation keeps the zero spade at around cathode potential. The neon bulbs take no part in this operation since the by-pass capacitor C14 across the cathode resistor and C3, the by-pass on the spade buss potential, hold their voltages constant during the 10 microsecond clear-set pulse.

Comparitive waveforms are shown in Fig. 3.5-15

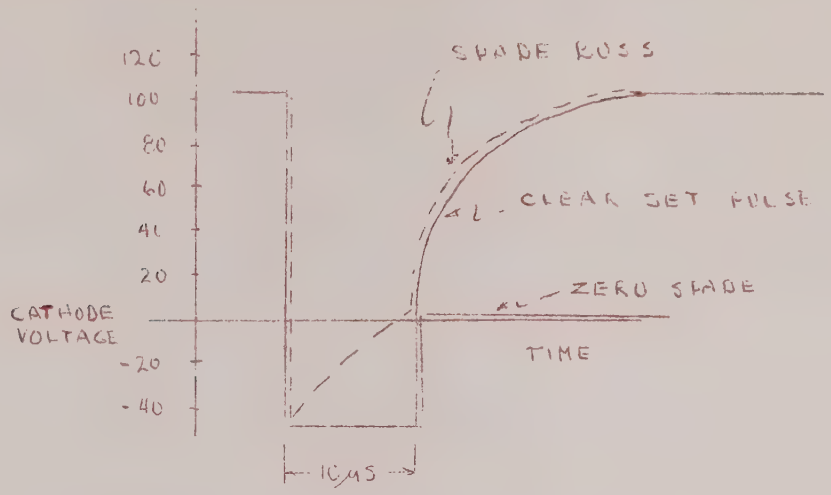


Fig. 3.5-15

The MBS tube may be clear-set to any desired number by replacement of the spade resistor with a network as shown in the zero spade. If the MBS tube is clear-set to an odd number, then the drive flip-flop must be reset to the opposite side to maintain the correct odd-even drive to the switching grids.

The grid return resistor R35 of the drive flip-flop normally is returned to -220 volts through an externally located diode. A negative pulse capacity coupled into the junction of R35 and the diode will drive the respective grid negative, causing that side of the flip-flop to cut off. The flip-flop will thus be reset to its starting or reset state. The positive transient at the end of the reset pulse will develop a negligible positive voltage across the forward impedance of the diode. The width of the reset pulse also acts as a gating signal to inhibit the flip-flop from being toggled by the previous MBS tube stage being clear-set to its zero spade. If the reset pulse were not wider than the 10 microsecond clear-set pulse, then it would be possible for a flip-flop to be reset to zero and then be toggled to its opposite state by the previous MBS tube stage being clear-set to zero.

Troubles in the beam tube stage will normally fall into one of the following categories:

1. Beam cannot be formed
2. MBS decade stage does not reset properly
3. The stage will not count
4. The tube counts erratically

In most cases difficulties which occur within the circuit will be due to tube failures. If replacement tubes are available, the most simple thing to do is to try replacing the flip-flop drive tube and the MBS tube to see if this clears up the trouble. In the event that this does not, it will be necessary to use an oscilloscope and a voltmeter to trouble-shoot the counting stage.

1. If the beam will not form, then the following points should be checked first:

   a) The supply voltages
   b) Open components in the spade or cathode circuits
   c) Tube not seated properly
   d) Too low or no filament voltage
   e) Defective tube
   f) Magnetic material in close proximity of the tube

2. If the beam will form, but the stage cannot be reset to zero then the waveform of the clear set pulse at various points in the circuit should be compared with those of figure 3.5-15. These waveforms should all be checked compared to the cathode voltage.

3. If the decade stage will not count at all then it should first be determined whether the fault is in the flip flop drive stage or in the MBS tube and its associated circuitry. The drive flip flop should be visually observed to see that its filaments are on. A simple test is to replace the drive flip flop with a tube from another counting stage. The input signal from the previous stage should be checked.

   If the drive flip flop is switching but the beam tube itself is not advancing then the voltage waveforms on the MBS tube grids should be checked. These measurements should, also, be observed with respect to the cathode to see that the proper bias is being maintained. The voltage levels of other points in the circuit such as the spade buss potential should be checked to see that they have the correct operating value.

4. If the beam tube counts but counts erratically, then the trouble is probably in the MBS tube. The operation of the

drive flip flop should be checked by observing its plate waveform. Erratic operation of the MBS tube will normally show up in one of two ways. The MBS tube will either skip one or more positions, or it will hold up momentarily on one or more of the positions. If the MBS tube skips one position then due to the odd even drive from the flip flop the MBS tube will normally wait at the next position until the flip flop catches up with it. In this manner it is possible for the MBS tube to operate erratically yet the final count to come out correctly. The defect would show up only if the final count to the MBS tube were on the unstable position. This type of failure is most easily checked by operating the MBS tube stage at a low enough rep rate to allow visual observation of the NIXIE numbers as the MBS tube is counting. Faulty operation of this type is normally corrected by replacement of the MBS tube, however, it is possible for it to be caused either by insufficient positive bias of the grids or the presence of magnetic material close to the MBS tube. The voltage of the conducting target should be checked to see that it is 70 or more volts positive with respect to the cathode.

If the MBS tube is observed to hang up in different positions then the voltage swings of the two grids should be checked with respect to the cathode to see that they are not biased too high positively and that the negative swing is of sufficient magnitude to cause switching. The presence of magnetic material should also be checked. The target potential should be checked to see that it is not too high requiring an excessive grid voltage for switching.

INTRODUCTION 4.1

The Model 1230 DC to Time Converter produces an output time interval which is proportional to the voltage applied to the input. When combined with a suitable counter and frequency source the Model 1230 may be operated as a digital voltmeter.

The Model 1230 is an all electronic instrument which utilizes a linear sweep generator. The output pulses are produced when the sweep voltage passes through zero volts and the applied input voltage after amplification or attenuation. The automatic polarity indication is produced by sensing which of the two pulses occurs last. The sweep generator is recycled by a control voltage supplied from the counter or indicator.

In addition to the output interval, a zero voltage reset signal is produced which enables the counter to display normally when the spacing between the pulses is less than the resolution time of the counter.

The polarity indication and indication of the position of the Range Selection switch are available as voltage levels for the operation of remote indicating devices and data recorders.

The self contained power supply provides the operating voltages for the internal circuits and power for the operation of the Model 1231 Digital Voltmeter Indicator.

CALIBRATION 4.2

When properly calibrated, the indication of the Model 1230 should be the calibration number when the Range Selector is placed in the CALIBRATE position, and zero in all other positions with the input open or grounded. When the reference voltage is measured in the CALIBRATE position the indication will vary plus or minus three counts; the calibration voltage should be in the middle of range of indications.

The calibration procedure must be performed in the order given below. Minor calibration should stop with step 9 a.

1. Instrument must have been on for at least one hour. If power is interrupted for a few minutes during set-up, allow 15 minutes warm-up.

2. -300 volt adjust (rear panel): Sets the voltage of negative supply; voltage should be -300 volts ±1%; noise less than 50 millivolts peak-to-peak.

Note: Section 3.5 precedes

3. +300 volt adjust (rear panel): Sets the voltage of the positive supply; should +300 volts, ±1% noise, less than 50 millivolts peak-to-peak.

4. "A" Waveform and "B" Waveform adjustments (right-hand gusset): Control the shape of the output of the two discriminators. These two controls are set to the middle of the range over which operation is obtained. The center of the range may be selected by observing the indication while adjusting the control. If the control is rotated out of the operating region the counter or indicator continue counting; the Model 1230 will automatically reset and start a new cycle after a fraction of a second; other counters must be reset to start a new cycle.

5. Apply approximately 10 millivolts to the input. Place range selector in the 10 volt position. Adjust Zero for equal positive and negative reading.

6. With same input, place range selector in 1 Volt position. Adjust input amp offset adjustment for equal readings for positive and negative input.

   NOTE: When the position of the offset control is changed, a large temporary change in the output voltage of the amplifier occurs immediately which returns to a stable value within a 30 seconds.

7. Re-check reading on 10 Volt range and repeat step #5 if necessary.

8. Re-check readings on 1 Volt range and repeat step #6 if necessary.

9. Repeat until zeroed on both ranges.

9a. Set Calibrate adjustment so that indication equals the calibration number.

10. Place 1230 in 10 Volt range. Apply -10 volts. Adjust CALIBRATE to produce a reading of -10.000.

11. Place 1230 in 1 Volt range. Apply -1 volt. Adjust 1 Volt Adjust produce a reading of -1.0000.

12. Place 1230 in 100 Volt range. Apply -100 volts. Adjust 100 Volt Adjust to produce a reading of -100.00.

13. Place 1230 in 1000 Volt range. Apply -1000 volts. Adjust 1000 volt Adjust to produce a reading of -1000.0 volts.

14. Re-check zero adjustment. (See steps 5 & 6).

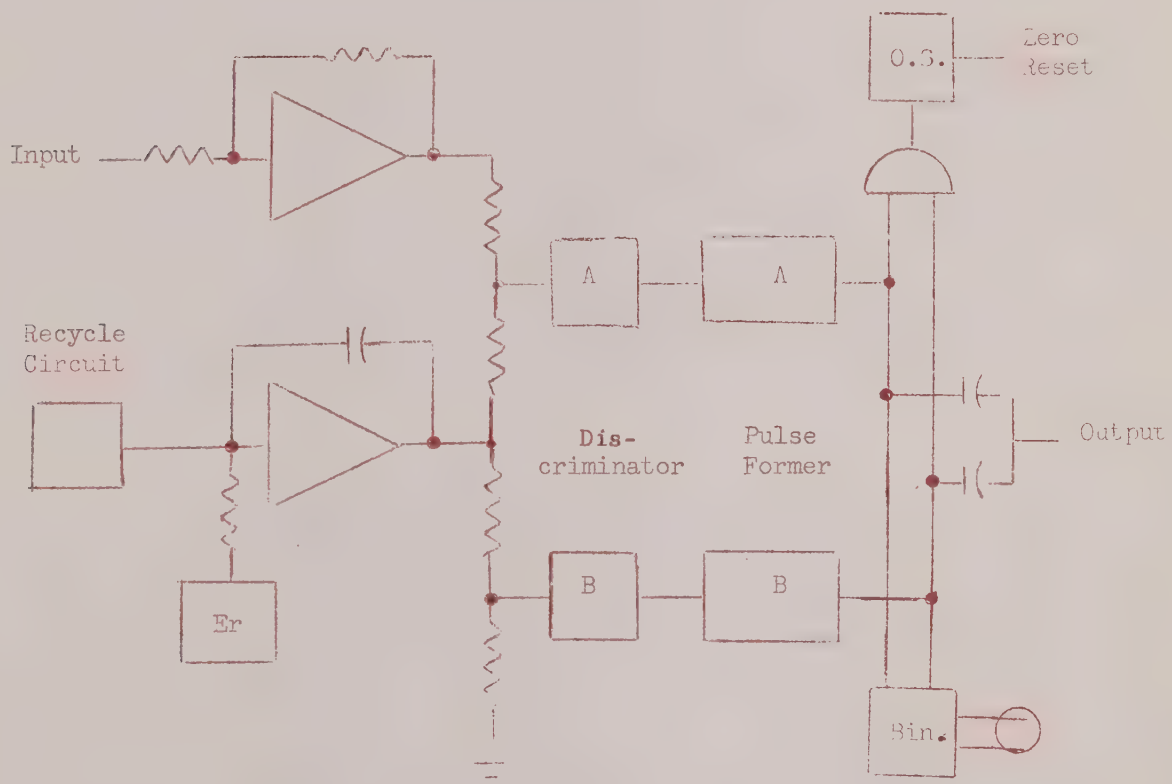
15. Check linearity using 100 volt range by applying -100, -90, -80, -70, -60, -50, -40, -30, -20, -10, +10, +20, +30, +40, +50, +60, +70, +80, +90, +100. All readings should be within ±5 count of applied voltage.

16. Switch to CALIBRATE. Note calibrate indication. This number is marked near the Calibrate control during factory calibration. Normally there should be no neccesity to re-adjust the range trimmers. The only calibration adjustments normally needed are the zero adjustments and then setting the Calibrate adjustment to produce the same indication as the calibration number.

CIRCUIT THEORY

Overall Operation

The basic units of the Model 1230 are shown in figure 4-1.



MODEL 1230, BLOCK DIAGRAM
Figure 4-1

The ramp generator produces a linear ramp voltage from -45 volts to +45 volts. The output of the ramp generator is used to drive the inputs to two sets of summing resistors which provide the input to the two voltage discriminators. The other input the signal summing pair is the output of the input amplifier. The input to the other pair summing resistors ground.

The two discriminators produce an output signal when their input voltages pass through zero volts. Thus as the ramp voltage goes from its negative voltage to its positive voltage an output is produced by each discriminator which is amplified and shaped into a negative pulse by the pulseformer circuits. The pulse from the "A" channel is produced when the ramp voltage is equal and of opposite polarity to the output of the input amplifier; the pulse from the "B" channel is produced when the ramp voltage is zero. The spacing of these pulses is determined by the input voltage and the rate at which ramp voltage changes. Since voltage of the ramp changes linearly with time, the time between the pulses is proportional to the output of input amplifier.

The two output pulses are combined to produce the two consecutive pulses which form the time output of the converter. The pulses are also combined through an "and" gate which triggers a one-shot multivibrator which produces the zero reset signal if the pulses are within one microsecond.

The two pulses are also used to set the polarity indication binary. The pulse which occurs last determines which way the binary is set.

The recycle circuit returns the ramp to its negative voltage ready to start a new sweep on command from the counter or indicator which is operated on from the Converter.

Input Amplifier 4.3-2

The input amplifier system consists of a stabilized D.C. coupled operational amplifier with feedback controlled by the Range Selector. It is operated at four gain settings; 40 for the 1 volt range; and 4 for the 10 volt range, etc. The full scale output voltage of the amplifier is 40 volts and of opposite polarity to the applied input. Trimmers allow the gain for the various ranges to be adjusted so that the output voltage for all ranges is the same.

Ramp Generator 4.3-3

The ramp generator consists of a stabilized DC coupled operational amplifier surrounded by an intergrating network. The input voltage is provided from a precision reference source of approximately seven volts. The voltage at the output of the circuit rises linearly at a rate determined by the resistance, capacitance and reference voltage.

$$\text{Volts per second} \cong \frac{E}{RxC}$$

The Calibration Adjustment varies the resistance so that the ramp may be adjusted to allow for the tolerances in the capacitor, reference voltage, and output voltage of the input amplifier. The ramp sweeps from at least -45 volts to more than +45 volts at a rate of 4 volts per millisecond.

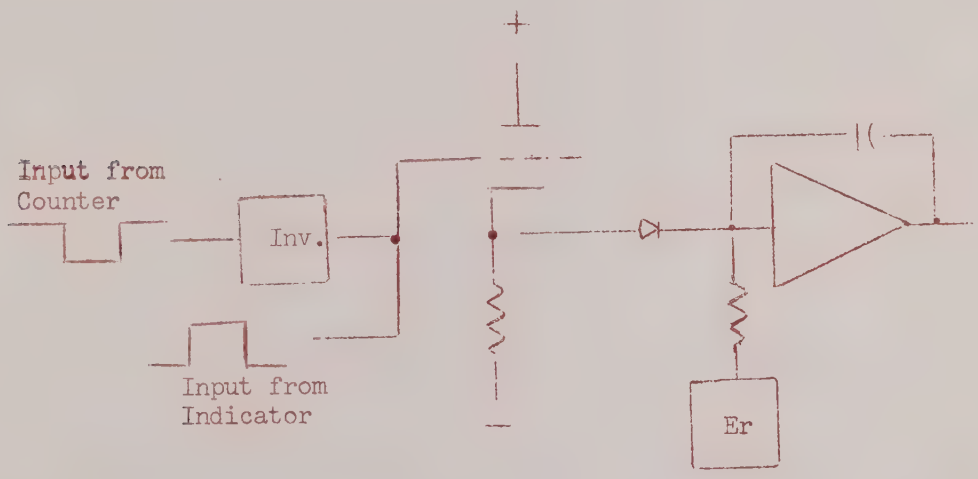
Reference Supply 4.3-4

The reference supply consists of a zener diode placed in a temperature controlled oven. It is supplied through a 30 kilohm resistor from the -300 volt supply.

Ramp Recycle Circuit 4.3-5

The ramp recycle circuit accepts the recycle command from the counter or indicator and returns the ramp to its negative voltage.

The circuit is shown in simplified form in Figure 4-2.



RECYCLE CIRCUIT
Figure 4-2

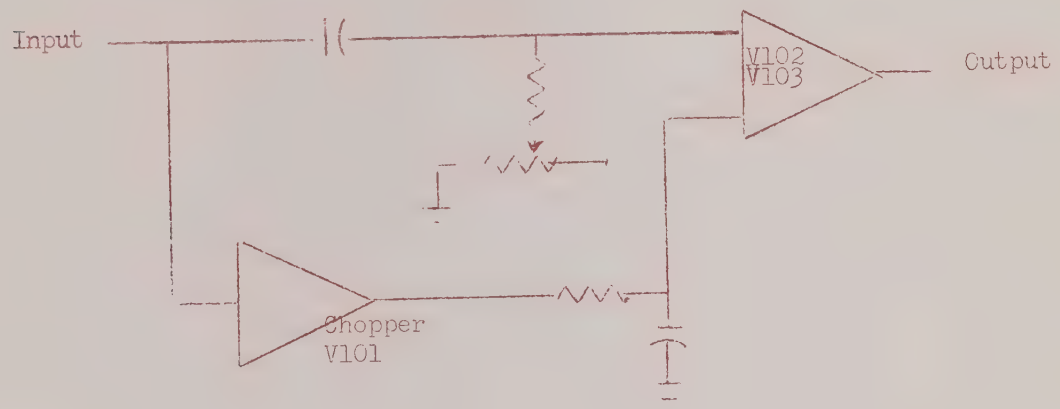
The cathode follower provides a positive voltage at a low impedance which returns the output of the ramp generator to its negative voltage quickly, the circuit constants during recycle being the voltage from the cathode follower and the impedance of the cathode follower. When the recycle signal is absent, the circuit is disconnected through the high reverse impedance of the silicon diode.

The timing of the recycle signal depends on whether the Converter is operated from the Model 1231 Indicator or a Systron counter. When operated from the Indicator the recycle signal is generated when the second output pulse is produced and remains until the completion of the display period of the Indicator.

In the case of operation with the Counter, the recycle signal is generated at the end of the display period and lasts for 5 to 10 milliseconds.

Amplifiers 4.3-6

The amplfiers used in the input amplifier and ramp generator are stabilized dc coupled amplifiers of conventional design. Each consists of two sections as shown in figure 4-3.



AMPLIFIER
Figure 4-3

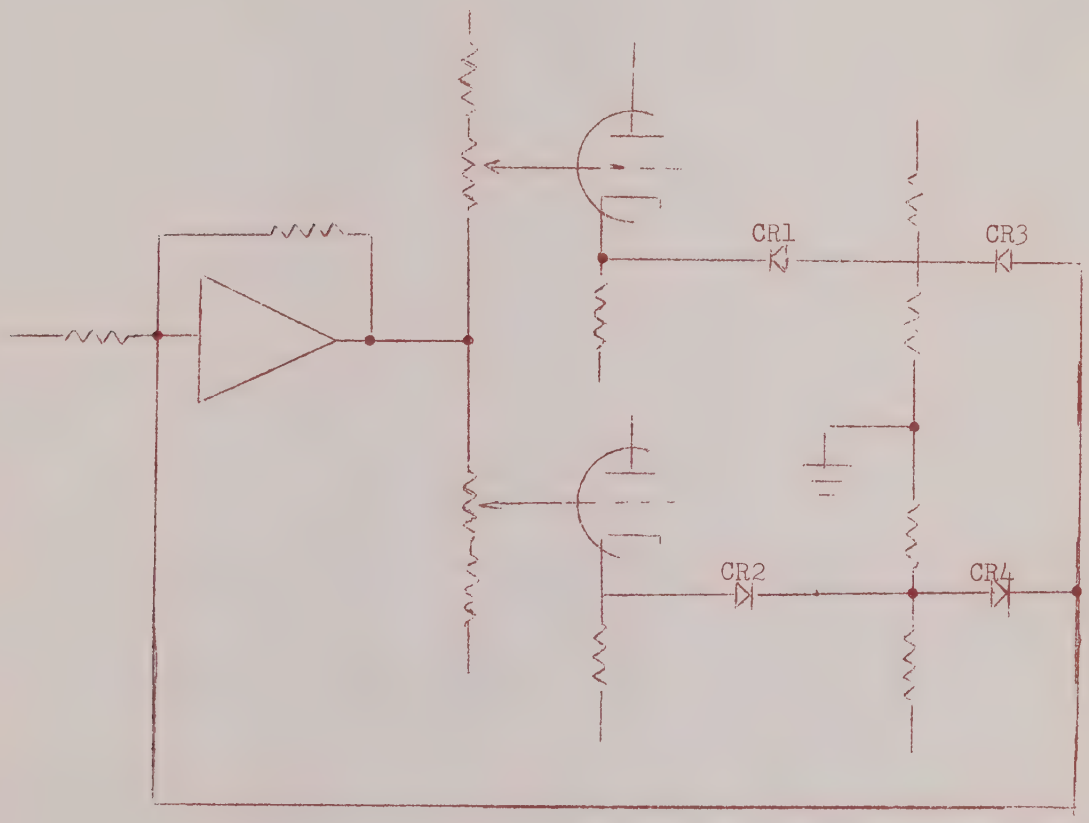
The input signal is connected directly to chopper section which has a high dc gain and capacitively coupled to the vacuum tube differantial section.

D.C. and low frequency signals will be amplified and inverted by the chopper section and applied to the positive input of the differential section. Frequencies above these are amplified directly by the differential section. When feedback is connected around the amplifier, the chopper section acts to keep the input to the amplifier at zero volts. The offset control allows this to be adjusted to exactly zero.

Clamp Circuits 4.3-7

Each amplifier is provided with a clamp circuit which prevents the amplifier output voltage from being limited by the amplifier itself which would result in an over-load condition requiring several seconds to restore. The output of the amplifier is connected to two voltage dividers as shown in figure 4-4.

When the output voltage of the amplifier reaches one of the limits set by the voltage dividers the voltage at one or the other cathode followers causes one of the sets of diodes to conduct and provides a low impedance feedback path to the input of the amplifier which reduces the gain to a very low value. The diodes CR3 and CR4 have a very high reverse impedance which prevent unwanted current flow to the input of the amplifier when the clamp circuit is not in operation. The reverse voltage across the diodes is limited by a second voltage divider.



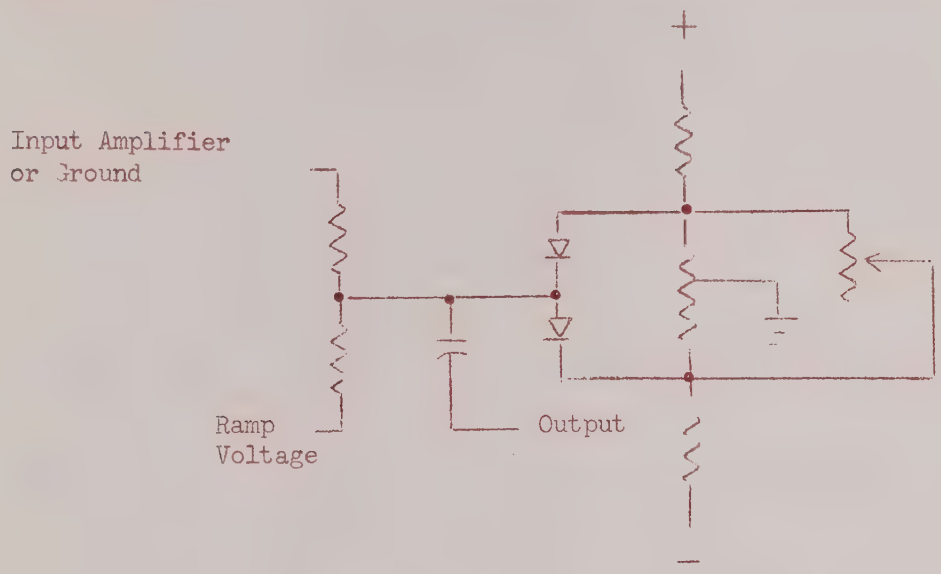
CLAMP CIRCUIT
Figure 4-4

Adjustments are provided so that the clamp voltage may be set to ±45 volts for the input amplifier and ±50 volts on the ramp generator.

Voltage Discriminators

4.3-8

The two voltage discriminators are similar. The circuit is shown in figure 4-5.



VOLTAGE DISCRIMINATOR
Figure 4-5

The two diodes are operated with a very slight positive bias, less than that required for conduction. The output of the summing junction is applied to the junction of the two diodes. If the voltage at the summing junction is less than ground it is clamped by the lower diode, if it is above ground it is clamped by the upper diode, if it is at or near ground neither diode is grounded. The resulting waveform is represented in figure 4-6.

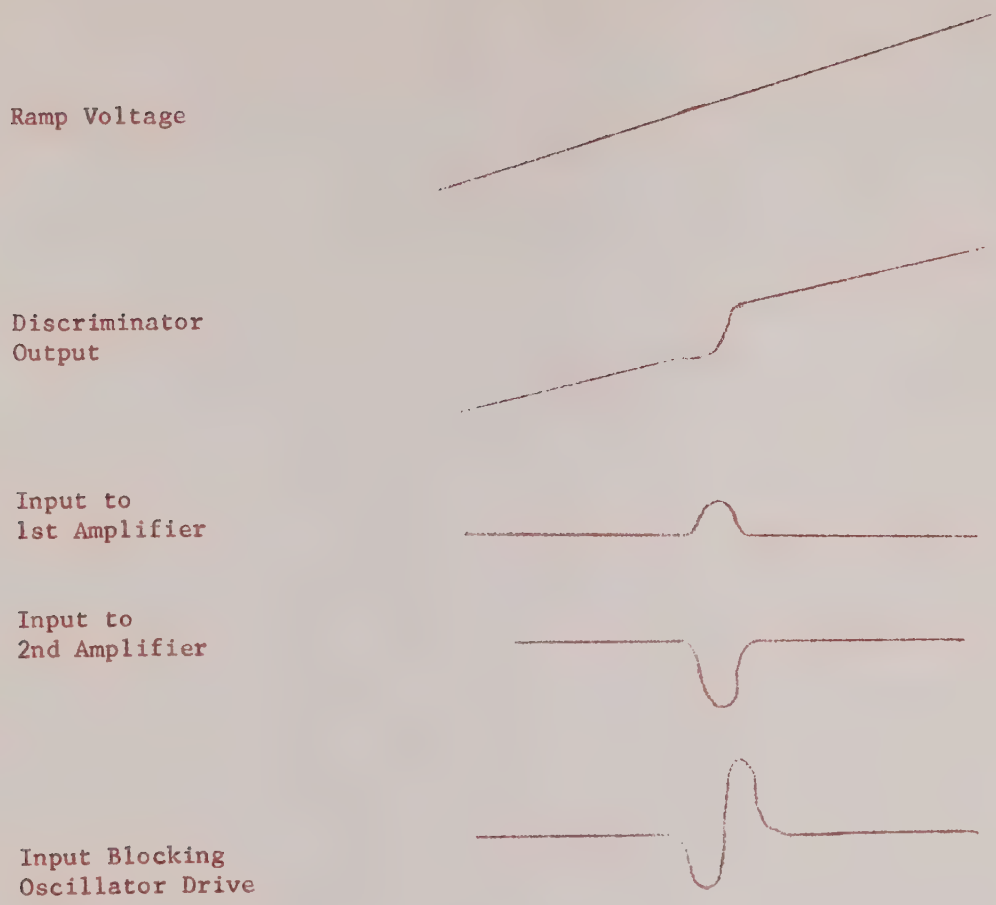
The rapidly changing portion of the voltage is coupled to the input of the pulseforming circuit.

Pulseforming Circuit

4.3-9

The pulseforming circuit contains two differenting amplifiers connected in series. The voltage waveform appearing at the grid of the first amplifier is shown in figure 4-6. The actual amplitude is very small compared to the output of the discriminator.

Note that the peak of the output pulse of the first amplifier occurs where the rate of change of slope the input signal is zero. This output pulse is conducted through a cathode follower to a second differentiating amplifier. Note that the point in its output where the rate of change of slope is zero (the fast rising portion between the negative and positive peaks) is coincident with the zero rate of slope change in the discriminator output voltage.



DISCRIMINATOR AND PULSE FORMER WAVEFORMS
Figure 4-6

The blocking oscillator which produces the output pulse is triggered on the fast-rising portion of the output of the second amplifier.

Because speurious outputs are produced by the voltage discriminator when the ramp generator is recycled, the blocking oscillators are inhibited from triggering during the recycle time. This signal is a positive voltage step from the recycle circuit which raises the cathode voltage of the blocking oscillator drivers so that the output of the amplifier does not trigger the circuit.

Output Circuit 4.3-10

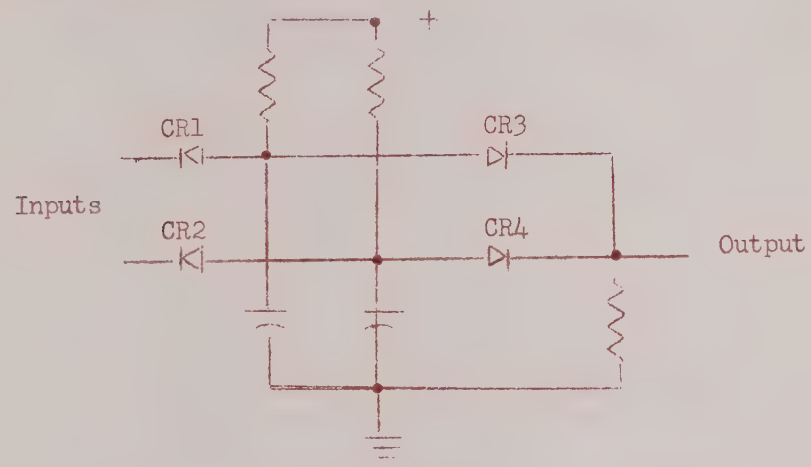
The outputs of the two pulseformer circuits are capacitively coupled to a common 100 ohm output resistance. The small coupling capacitor attenuates the 250 volt signal to about 10 volts. The signals from the blocking oscillator are conducted through reverse biased diodes to prevent coupling of ringing and other noise from the blocking oscillators.

± Binary 4.3-11

The ± Binary is triggered from the outputs of the two pulseformers. The output of one channel sets the binary to one side and the other channel to the other side. Since both pulses are produced each time the ramp voltage is generated, the binary is triggered each time except for the zero voltage case when the pulses are coincident. The pulse from the signal channel ("a" channel) sets the binary for "+" indication.

Zero Reset One-Shot 4.3-12

The zero reset one-shot produces a negative pulse when the outputs of the two pulseformers occur within two microseconds. The one-shot is triggered through an "and" gate shown in figure 4-7.



"AND" GATE
Figure 4-7

If a negative pulse is applied to both inputs simultaneously. The voltage at the junction of CR3 and CR4 will drop producing a negative to trigger the one-shot.

The one-shot is also triggered by the normal reset pulse from the counter or indicator

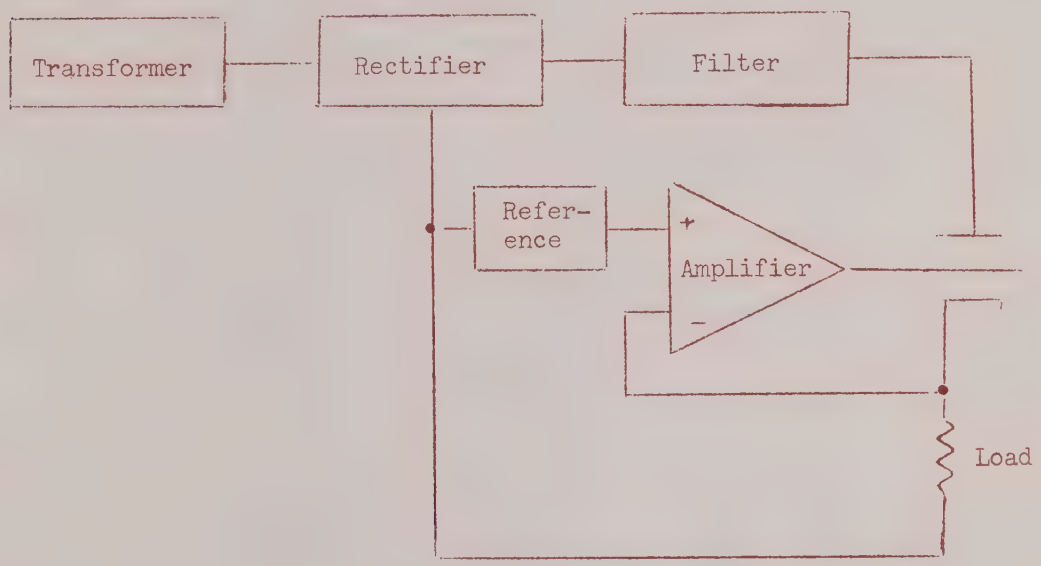
Power Supply 4.3-13

The Power Supply contains two conventional series regulated supplies to provide the regulated +300 volts and -300 volts. A seperate transformer supplies filament power; one of these windings is biased at -300 volts, the other is referenced to ground. A bridge rectifier circuit provides 6 volts dc to the two input tubes of the Converter input amplifier. A third winding provides 6.3 volts for the oven heater.

Connections are provided through J101 so that the additional regulator tube in the Model 1231 indicator is operated in parrallel with the regulator in the Model 1230.

The basic components of a series regulated supply are shown in Figure 4-8.

Each regulated supply consists of a transformer to convert the AC power source voltage to the required AC voltage, a rectifier to convert this AC voltage into pulsating DC voltage, and a filter to smooth out this pulsating DC. The output of this filter is unregulated DC voltage with a high ripple content. The magnitude of this unregulated DC voltage is directly dependent upon the voltage of the AC power source. This unregulated DC voltage is applied to the plate of a series regulator tube. This tube acts as a variable impedance in series with the load. Its impedance is varied to maintain the voltage across the load constant. As shown in Figure 4-8, its actual operation is that of a cathode follower.



BLOCK DIAGRAM POWER SUPPLY
Figure 4-8

The voltage to be regulated is fed into an amplifier circuit. Here it is compared with a fixed reference voltage. The output of this comparison is then amplified and fed to the grid of the series regulator tube or cathode follower. If the output voltage changes positively with respect to the reference voltage, the DC amplifier will feed a signal to the cathode follower grid, tending to drive its output negative. This feedback will thus tend to keep the output voltage at a constant value as determined by the reference input and the relative values of the comparison circuit. A capacitor C is placed across the load to give a low output impedance to high frequency transients.

If the supply is grounded at the cathode of the cathode follower then the supply generates a negative regulated voltage at the bottom of R load. If the supply is grounded at the bottom of R load, then the supply will generate a positive regulated voltage at the cathode of the cathode follower.

When both negative and positive regulated voltages are generated at the same time, it is possible to use the regulated output of the negative supply as the reference voltage for the negative supply should increase, causing the output voltage of the negative supply to increase, the output voltage of the positive supply will also increase. The two changes will tend to cancel out for loads connected between the two supplies.

The -300V supply uses a glow-discharge, voltage-reference tube, type 5651, as a reference element. This tube maintains a relatively constant voltage of approximately 87V across its two terminals over a range of operating current of 1.5 to 3.5 milliamps. The 5651 supplies the cathode voltage of the DC amplifier, V18. Resistors R20 and R22 in connection with potentiometer R21 form the input to the amplifier circuit. They apply a percentage of the regulated output voltage to the grid of V18. Any change in the output voltage with respect to the 5651 reference tube will be a change in the grid to cathode voltage of V18. The change will be amplified by V18 and will appear on the grid of V17B as negative feedback tending to cancel the change out. In this manner the series regulator compensates for changes in the AC supply voltage and load variation. C5 couples the higher frequencies to the amplifier, the comparison circuit for improving the power supply transient response.

Resistors R17 tends to balance the current in V17B and V101 in the Model 1231. These resistors also act as fuses to protect the more expensive power supply components in the event of an overload. R3, in addition to serving to limit the peak charging current into capacitor C2 also acts as a fuse to protect the rectifiers and transformer in the same manner as R17 and R18.

C7 is placed across the output to provide a low impedance to transients. Since an electrolytic capacitor has a small amount of internal inductance, a .01 microfarad disc, C9, is also placed across the output to maintain the low output impedance at very high frequencies.

The circuitry of the positive supply is identical with that of the negative supply except that the cathode of the DC amplifier V16 is grounded and the amplifier input circuit, R19, R18, and R17 uses -300V as the reference voltage.

APPLICABLE SCHEMATICS
Lot 6 & UP
(Models 1230 and 1231)

1231-D4C	Digital Voltmeter Indicator
1231-B5	Function Indicator
1231-C2A	1MC Decade
1231-C1A	100KC Decade
1231-C3A	10KC Decade
1230-D3C	DC to Time Converter
1230-B1	Pulseformer
2976-B1B	Amplifier
1230-C2C	Power Supply

○ DENOTES CONNECTIONS TO U101, INPUT AXLE 50 PG.

□ DENOTES CONNECTIONS TO U102 DIGITAL OUTPUT.

1 MEGACYCLE OSCILLATOR

GATE

DECADES AND BUFFER

DIGITAL OUTPUTS

1 MC DECADE 1231-C3A

100 KC DECADE

10 KC DECADE 1231-C3A

10 KC DECADE 1231-C3A

FUNCTION INDICATOR 1231-B5

GATE VOLTAGE

END OF COUNT

EXTINGUISH CIRCUIT

RECYCLE

AUTO-START ONE-SHOT

FLIP-FLOP

DISPLAY GENERATOR

RESET ONE-SHOT

END OF JOUNT

B- TO OVER-RANGE BINARY

RESET INHIBIT

(A) +300V

(B) -210V

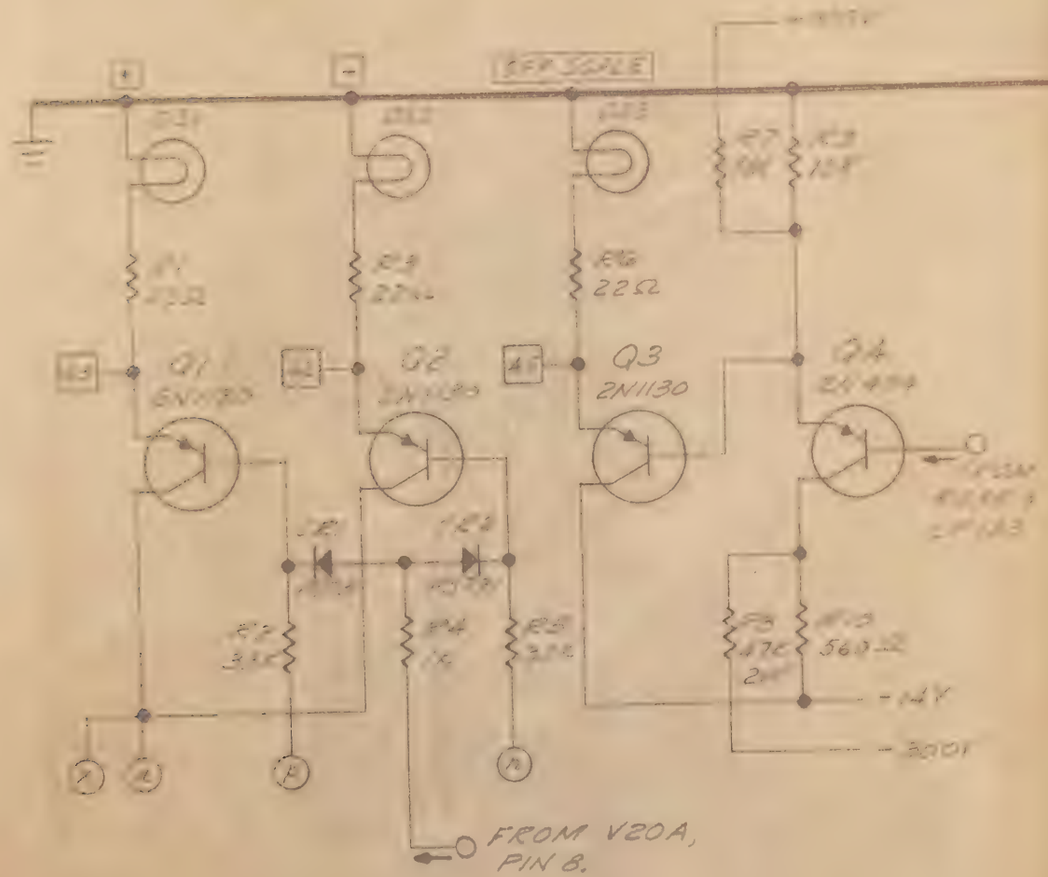
(C)

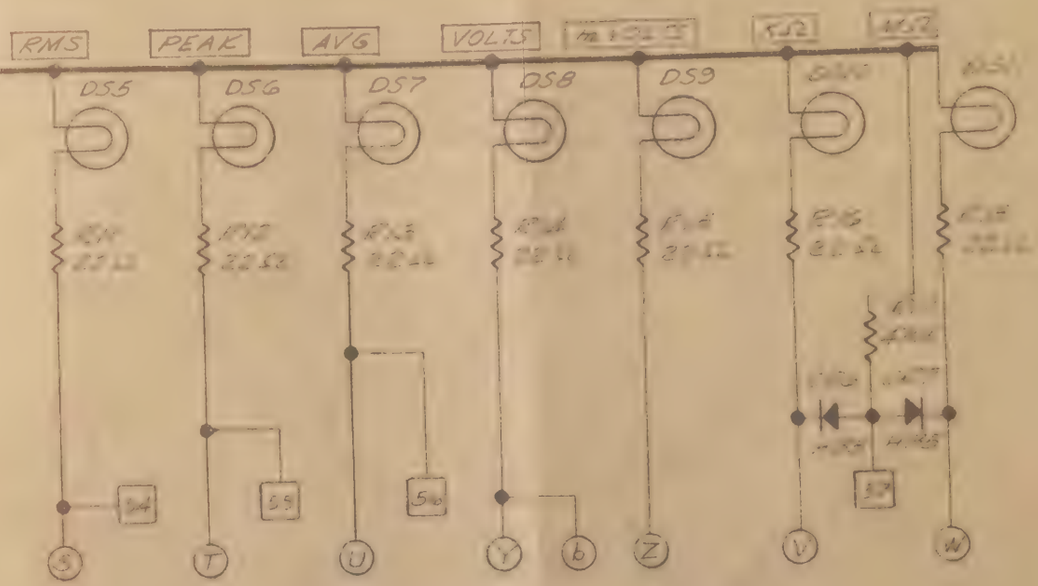
(D)

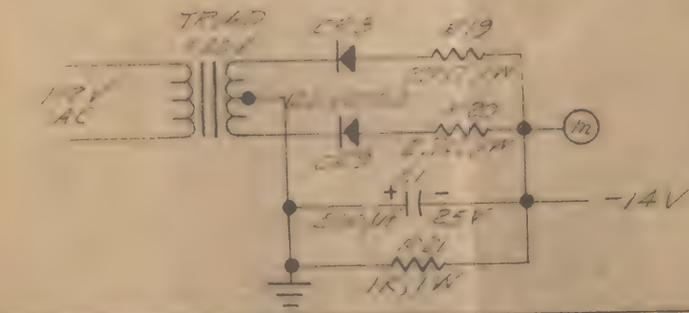
117V AC

-300V (OPEN IN FULL CW POSITION)

SER.	ISSUE	ECO NO	REVISIONS	APPR	
193	A	236	[illegible]	TTM	[illegible]







NOTE:
UNLESS NOTED
1. ALL CAPACITOR VALUES GREATER THAN 1 ARE MFD.
2. ALL CAPACITOR VALUES LESS THAN 1 ARE MFD.
3. ALL CAPACITOR VOLTAGES 400V MIN.
4. ALL RESISTORS ½W 5%.
5. ALL LAMPS 14V, 80 ma.

SUPERCEDES	QTY.	USED ON	REF.	NUMBER	DESCRIPTION	QTY

MATERIAL

FINISH

UNLESS OTHERWISE NOTED TOLERANCES

FRACTION ± 1/64 | ANGULAR ± 0° 30'
XX ± .020 | THREADS CLASS 2
XXX ± .005 | MACH. SURF. √

DO NOT SCALE DWG.

SYSTRON-DONNER CORPORATION
CONCORD CALIFORNIA

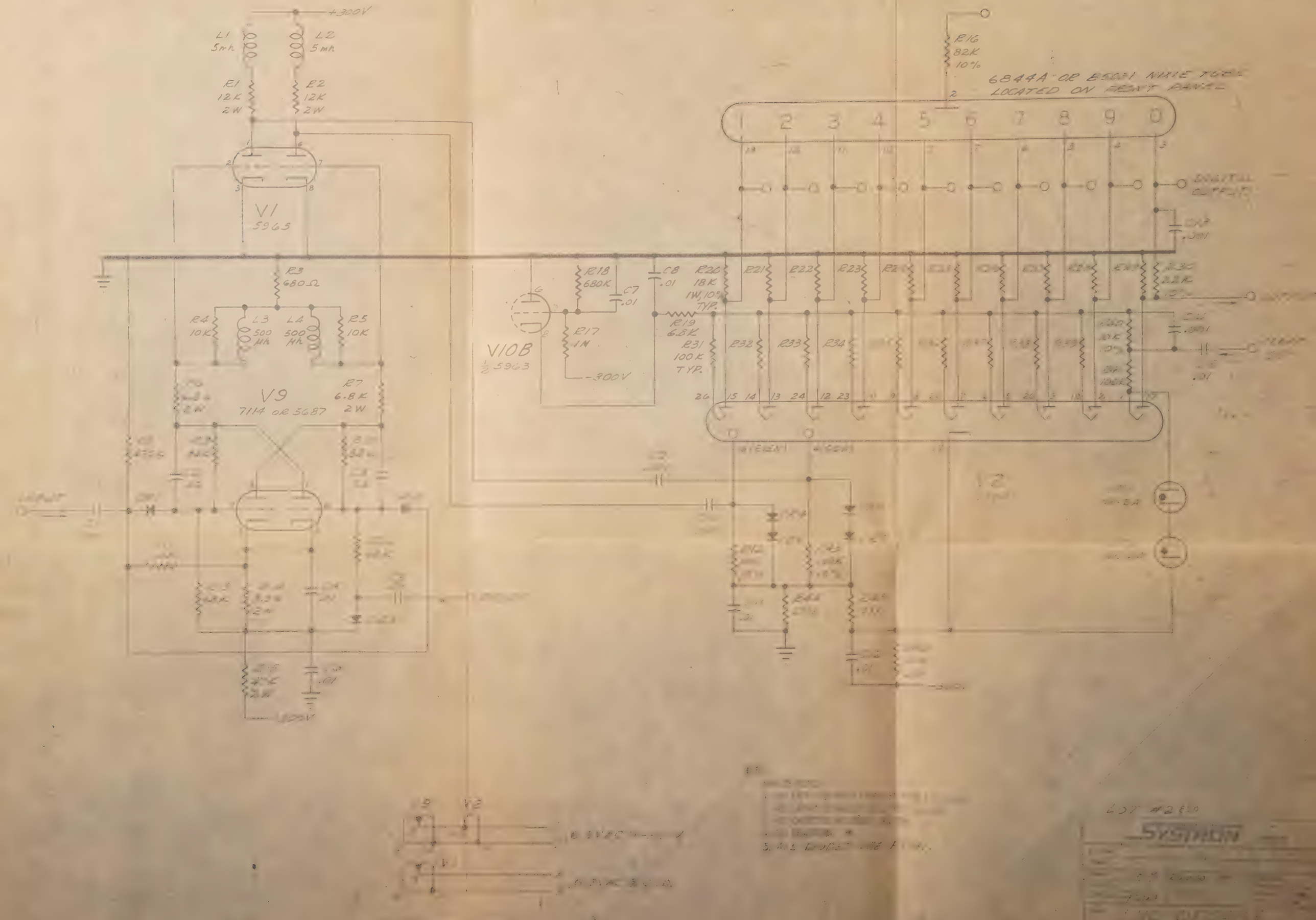
DRWN.
CHK D.
APPR.
SCALE

MODEL 1231

TITLE FUNCTION INDICATOR

DWG NO 1231-B5

ISSUE


+300V
L1 5mh
L2 5mh
R1 12K 2W
R2 12K 2W
V1 5963
R3 680Ω
R4 10K
L3 500 Mh
L4 500 Mh
R5 10K
V9 7114 OR 5687
R7 6.8K 2W
R16 82K 10%
6844A OR ESO21 NIXIE TUBE
LOCATED ON REAR PANEL
1 2 3 4 5 6 7 8 9 0
R18 680K
C7 .01
C8 .01
V10B 1/2 5963
R17 1M
-300V
R19 6.8K
R20 18K 1W, 10% TYP.
R21
R22
R23
R31 100K TYP.
R32
R33
R34
20 15 14 13 24 12 23

R12
82K
10%

6844A OR B5031 NIXIE TUBE
LOCATED ON FRONT PANEL

1 2 3 4 5 6 7 8 9 0

R37
100K
10%

V4
6770

LOT #2

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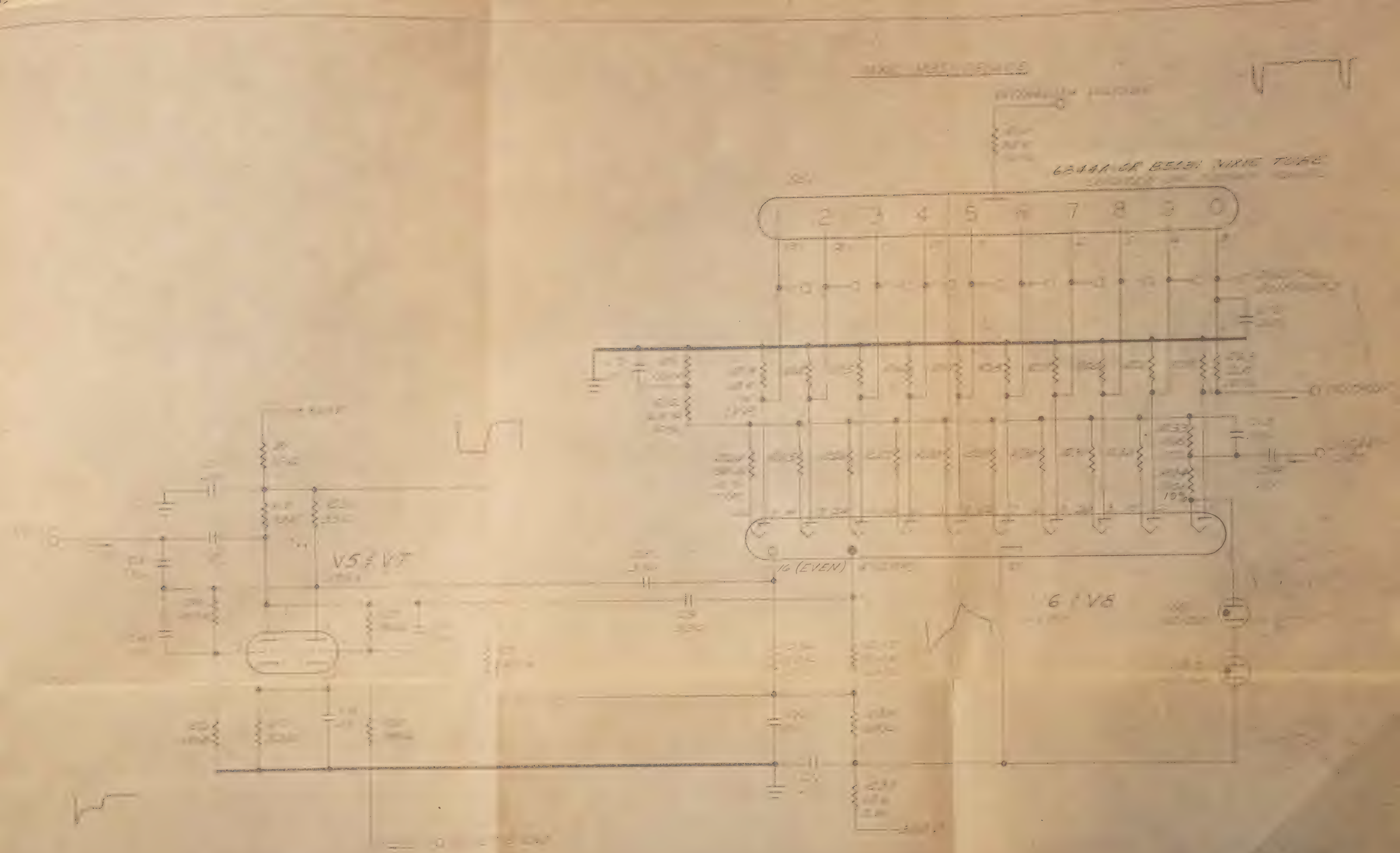

6844A OR B52B1 NIXIE TUBE
1 2 3 4 5 6 7 8 9 0
V5 & V7
16 (EVEN)
6 / V8
10%

INPUT DISCRIMINATOR

+300 V, DECOUPLED

R128 70K

"A" WAVEFORM

R130 300Ω

C109 .01

R129 70K

-300 V, DECOUPLED

V1, V2, V3, V4

PULSEFORMER

DWG 1230-B1

POWER SUPPLY

V5

6.3 V TO HEATER (+)

ZERO RESET ONE SHOT

R176 100Ω

+300 V

ZERO RESET OUTPUT

V11C

5965

R175 2.2M

-300 V

± 45 VOLT RAMP GENERATOR

6.3 V AC 3 GND

C127 .05

AMPLIFIER DWG 20

6.3 V AC 3 GND

R213 75K 2W

R212 75K 2W

OA3 V

R179 36K 5W

CALIBRATE

R178 10K

C126 .05

-300 V

C128 .01

6.3 V AC FROM POWER SUPPLY

PULSEFORMER INHIBIT

RAMP VOLTAGE

+100 V

LIMIT

R165 2.2M

R166 1M

R187 47K 2W

R182 2.2M

V14

5965

C133 PS615

-300 V

ZERO DISCRIMINATOR

+300 V, DECOUPLED

R196 70K

"B" WAVEFORM

R139 70K

-300 V, DECOUPLED

V6, V7, V8, V9

PULSEFORMER

DWG 1230-B1

OUTPUT

-300 V

6.3 V AC 3 GND

V11C

5965

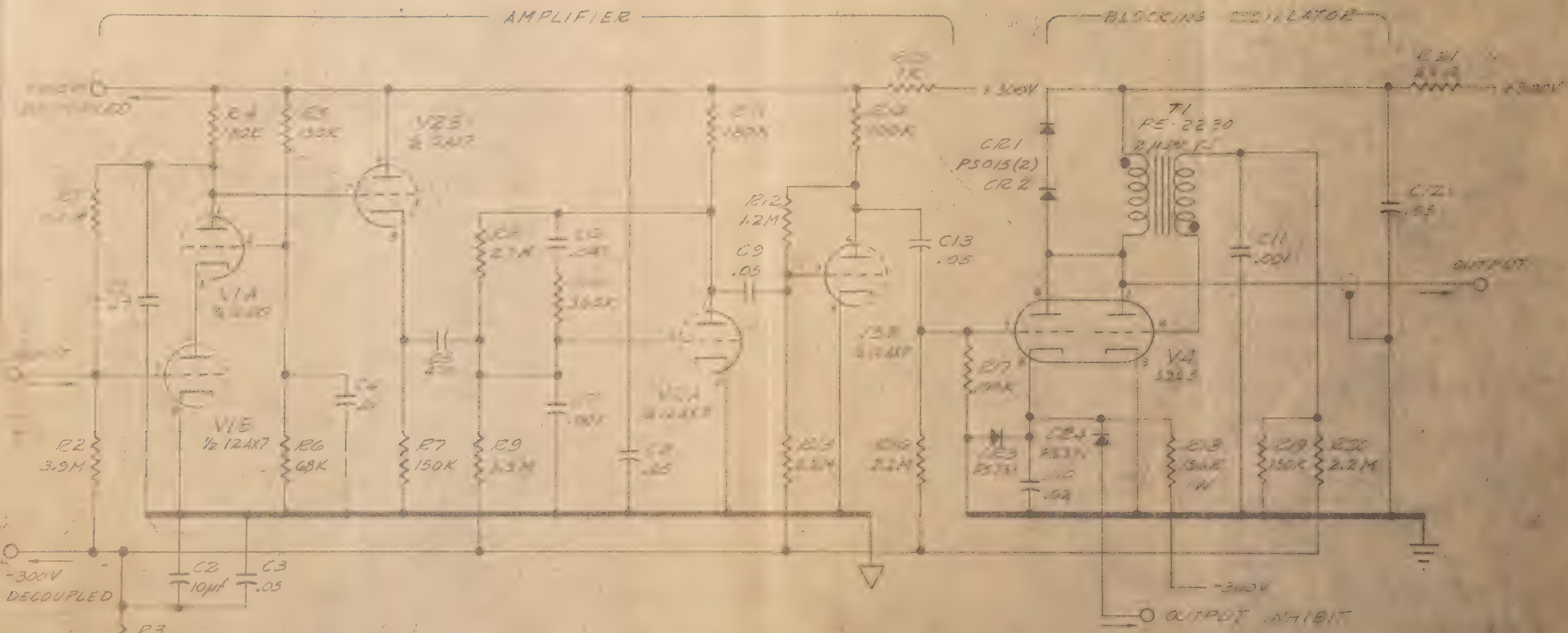
R175 2.2M

-300 V

5. ▽ SIGNAL GROUND

6. □ DENOTES CONNECTION TO J101 RANGE CONTROL & INDICATION

7. * THESE TUBE ARE PROVIDED ONLY IN THE "F" MODIFICATION



NOTE:

UNLESS NOTED

1. ALL CAPACITOR VALUES GREATER THAN 1 IN MMFD.
2. ALL CAPACITOR VALUES LESS THAN 1 IN MFD.
3. ALL CAPACITOR VOLTAGES 400V MIN
4. ALL RESISTORS ½ W, 5 %.
5. [illegible]

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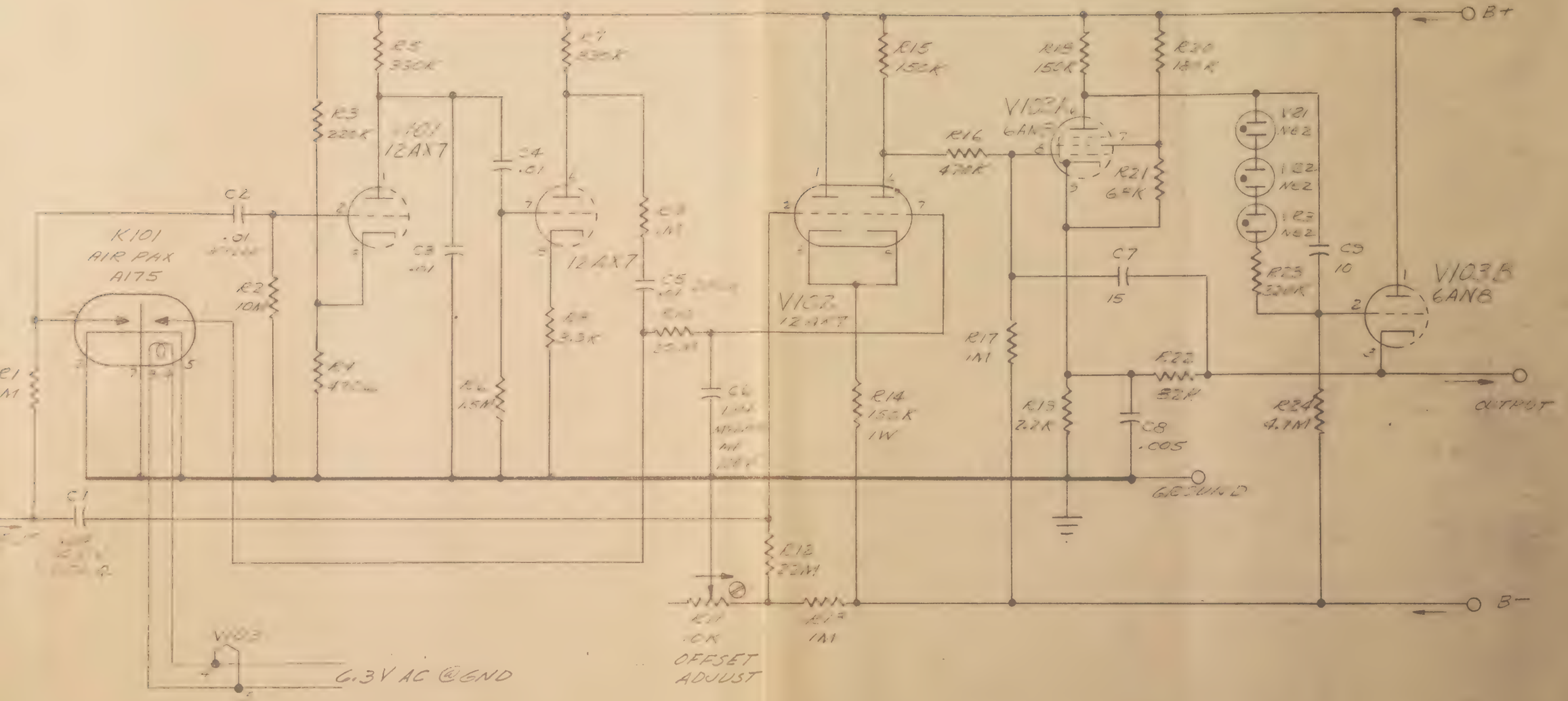
T. W. 3-23-60

OUTPUT PULSE FORMER

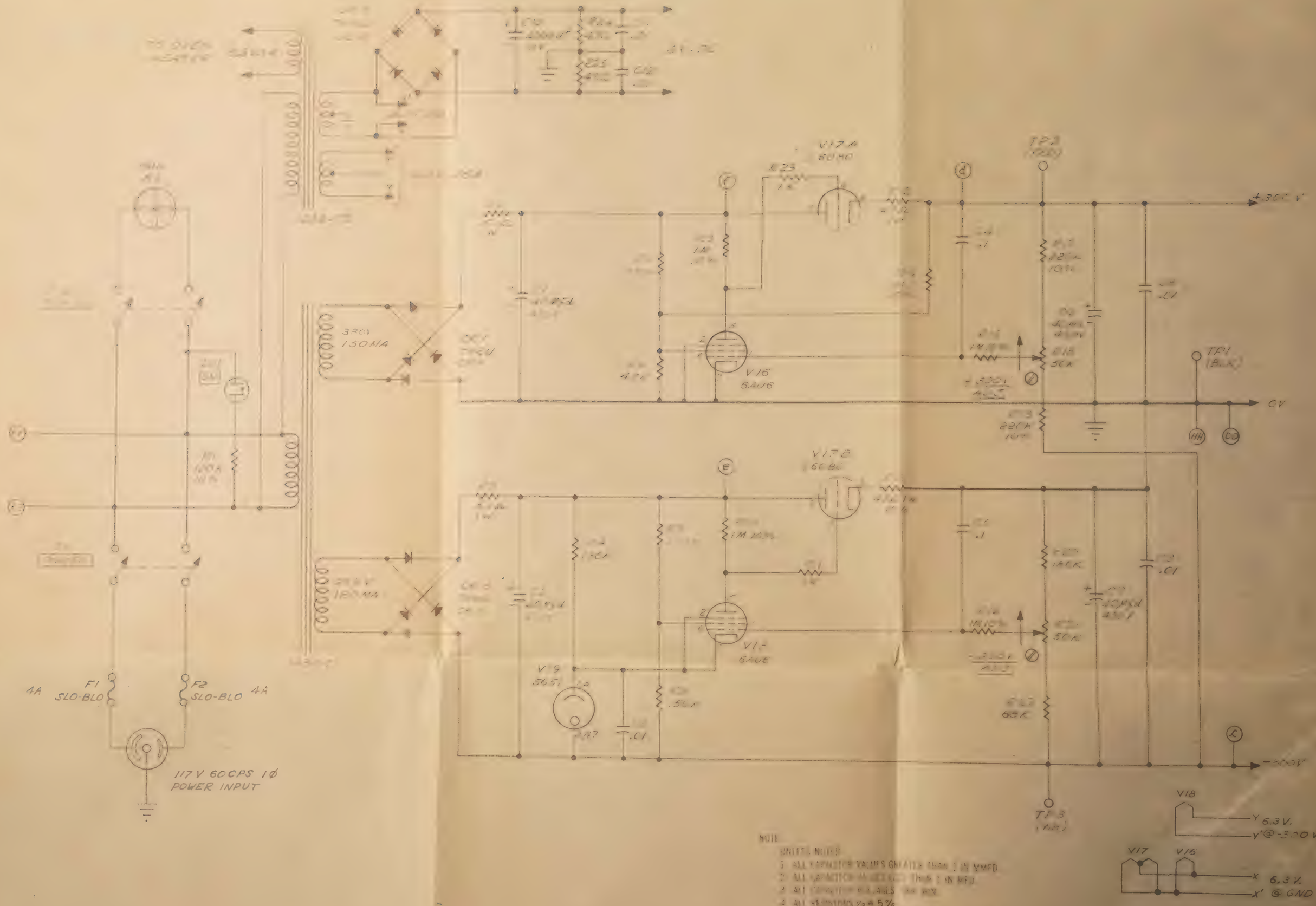


UNLESS NOTED
ALL CAPACITOR VALUES GREATER THAN 1 ARE MFD
ALL CAPACITOR VALUES LESS THAN 1 ARE MFD
ALL RESISTORS WATTAGE 1/4
ALL RESISTORS ± 5%.

DRAWN	12-[illegible]
CHKD	1-2[illegible]
APPD	[illegible]

AMPLIFIER MODULE

2976 2976-B1



NOTE

UNLESS NOTED

1. ALL CAPACITOR VALUES GREATER THAN 1 ARE MMFD
2. ALL CAPACITOR VALUES LESS THAN 1 ARE MFD
3. ALL CAPACITOR VOLTAGES 600 MIN.
4. ALL RESISTORS ½W ± 5%
5. CR1 THRU CR4 (IN4005 OR EQUAL)
   CR5 THRU CR12 (IN4148 OR EQUAL)
6. ◯ = PINS ON J101

SYSTRON DONNER

POWER SUPPLY

1230

1230-C2C

SYSTRON-DONNER CORPORATION

WARRANTY

Systron Corporation warrants each standard instrument or system manufactured by them to be free from defects in material and workmanship for a period of one year from date of shipment. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts, except vacuum tubes, at no charge. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case an estimate will be submitted before the work is started.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the agent and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

SYSTRON CORPORATION
950 Galindo Street
Concord, California

www.manualsplus.com
1029717